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GROUNDWATER REMEDIAL INVESTIGATION AND FEASIBILITY STUDY REPORT FOR THE TRW SITE IN MINERVA, OHIO

Final Report

Prepared for:

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II. REMEDIAL INVESTIGATION

Task 1. Description of Current Situation

a. Site Description

The TRW site is located in the town of Minerva, Stark County, Ohio. The plant site is adjacent to State Road 183, approximately 1.3 miles northeast of the intersection of Route 183 and U.S. Route 30, as indicated in Figure 1.

The initial site was purchased in 1954 and has been expanded twice by the subsequent purchases of adjacent properties. Property boundaries and other site features are depicted in Figure 2. The plant lies on a relatively flat, 54-acre parcel with farmland located to the north and east. TRW also owns 56 acres of hilly terrain west of Route 183. Except for a narrow strip immediately adjacent to Route 183, however, the property west of 183 has never been developed and is not a focus of this study. The approximately 25-acre parcel south of the plant, which extends to Sandy Creek, was purchased by TRW from R.F. Fry in 1982 and is now referred to as the South Property. In 1984 TRW also purchased a 250-foot wide strip of land east of the plant site, which extends to the Stark County line, from R and M Unkefer. This will be termed the East Property.

In addition to the plant itself, important features located on the TRW property include a drainage swale running along the eastern and southern borders of the plant; an ornamental

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5. Letter from TRW to Stark County Health Department
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I. INTRODUCTION

The groundwater study documented in this report is part of a wider study of PCBs and volatile organics conducted at the TRW site in Minerva, Ohio. Other parts of the wider study have been documented in a series of earlier reports which are referenced here as appropriate. The evaluation and design of surface remediation at the site was also presented previously. This groundwater study was designed to characterize the extent of volatile organic contamination detected in groundwater in previous analyses and to develop the information necessary to design and evaluate appropriate groundwater remediation. This report therefore focuses primarily on groundwater and on volatile organics. To facilitate evaluation, the format of this report parallels the "Generic Remedial Investigation/ Feasibility Study Statement of Work" (GSOW) provided to TRW by the Ohio Environmental Protection Agency (OEPA) in August 1984.

There are four major submittals that TRW has already provided to the United States Environmental Protection Agency (USEPA) and OEPA during the course of the studies conducted at the Minerva Site. These contain most of the information requested in the GSOW and will be cited frequently in this report. They are:

- Characterization, Risk Assessment and Remedial Action Plan for a PCB Spill at the TRW Site in Minerva, Ohio. Prepared for TRW, Inc., by Clement Associates, June 20, 1983 (Clement 1983a).

- Enclosure to Letter of December 20, 1983 from Mr. William R. Phillips (TRW) to Mr. Basil G. Constantelos (USEPA). Prepared for TRW, Inc., by Clement Associates, December 20, 1983 (Clement 1983b).

- Characterization, Risk Assessment, and Remedial Action Plan for Volatile Organic Contamination at the TRW Site in Minerva, Ohio. Prepared for TRW, Inc., by Clement Associates, August 27, 1984 (Clement 1984a).

- Surface Remediation Feasibility Study Report for the TRW Site in Minerva, Ohio. Prepared for TRW, Inc. by Clement Associates, Inc., November 16, 1984 (Clement 1984b).

The original work plan (and revisions) for the groundwater study was also provided previously. Accordingly, the "Amended Proposed Groundwater Treatment Feasibility Study for the TRW Site in Minerva, Ohio" is incorporated into this report as Appendix 1.

FIGURE 2

SITE PLAN AND BOUNDARIES OF THE TRW PROPERTY, MINERVA, OHIO

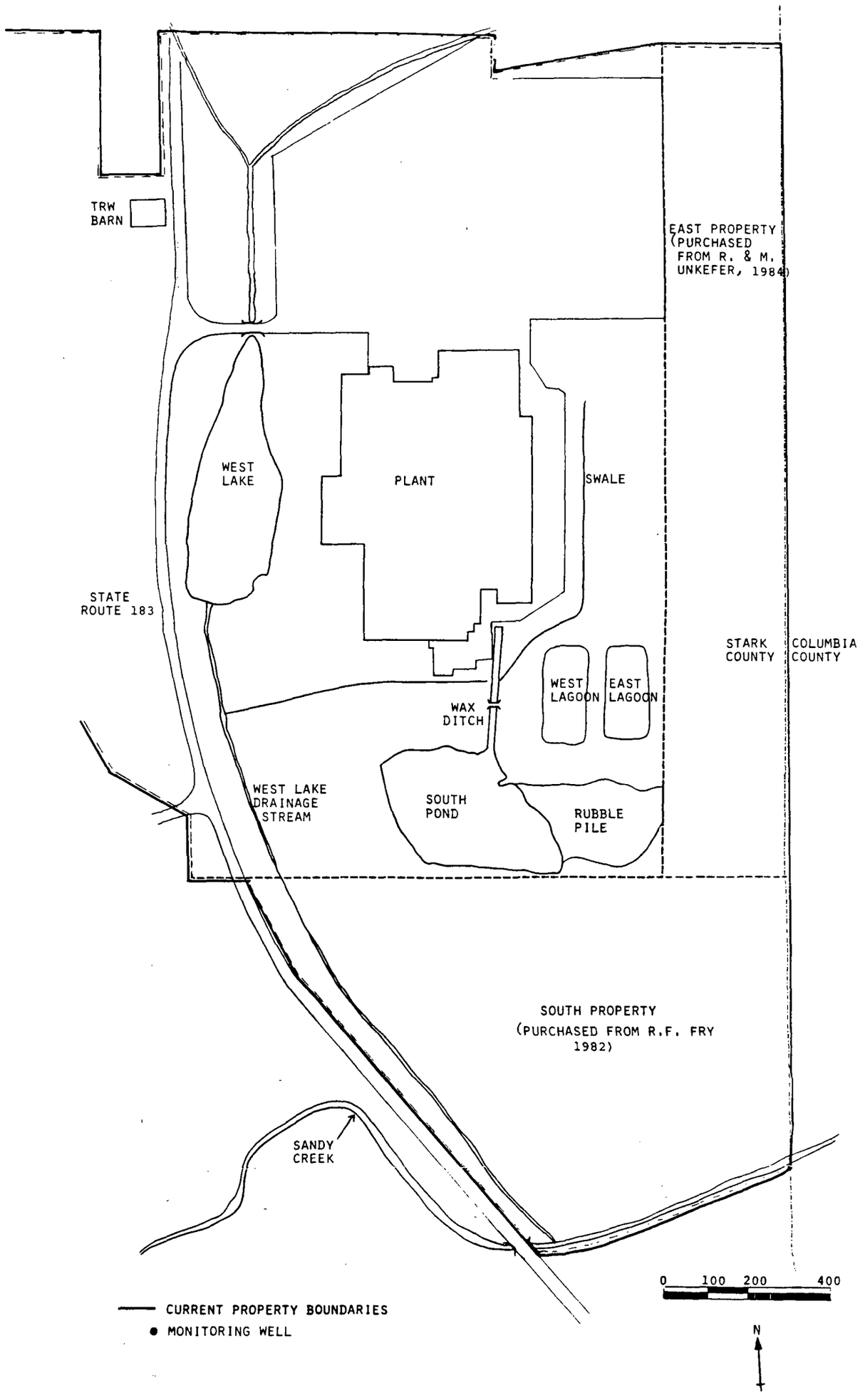

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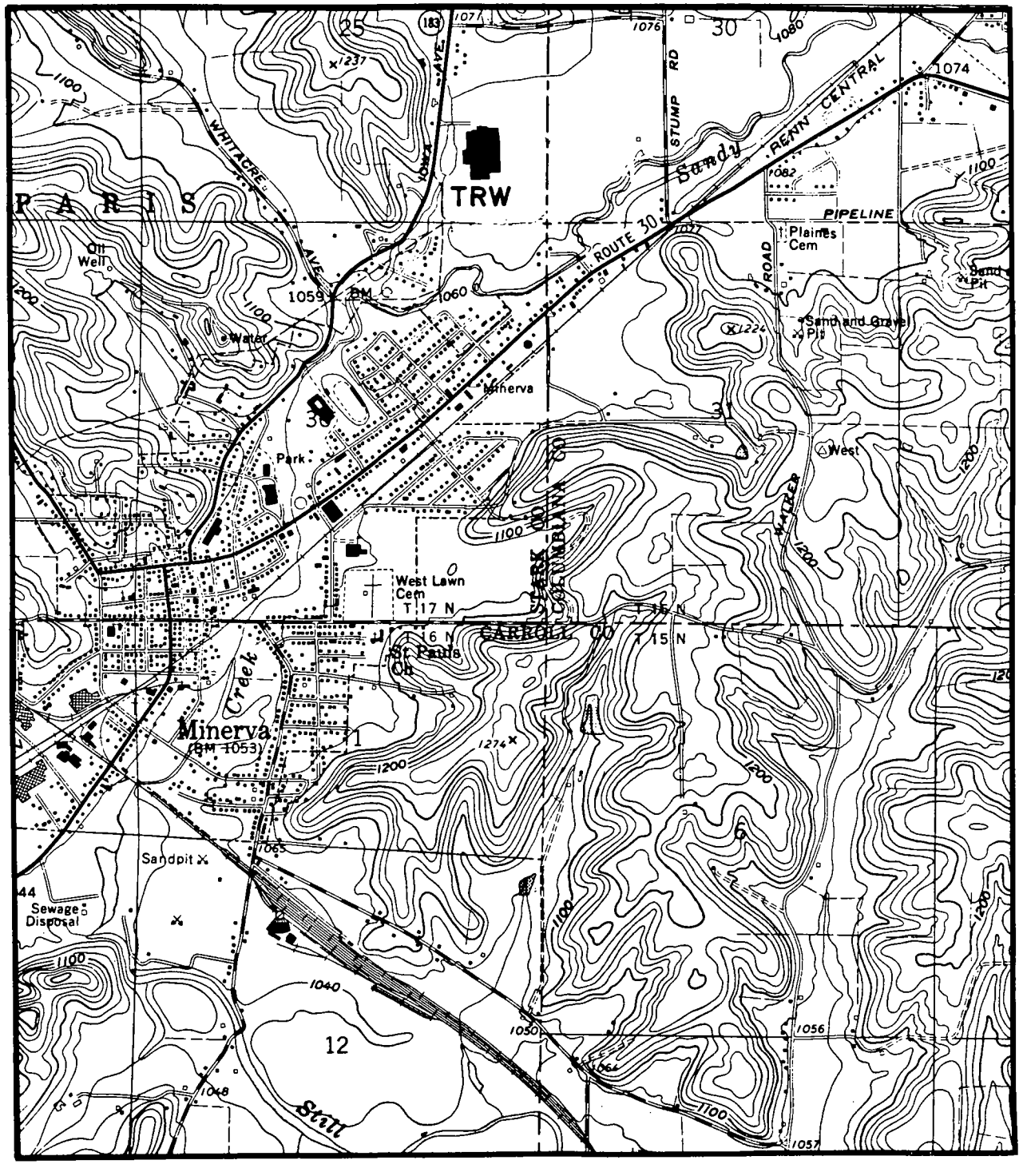
FIGURE 1

LOCATION OF THE TRW SITE IN MINERVA, OHIO



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lake, West Lake, located west of the plant; a discharge stream running from West Lake to Sandy Creek; a drainage lagoon, South Pond; the wax ditch, which runs from the plant to South Pond; and a rubble pile located east of South Pond. Thirty-two monitoring wells have also been installed on or near the property. A detailed physiographic description of the site is presented in the report submitted in June 1983 (Clement 1983a). A topographic survey map of the site is included in Appendix 2 of this report.

The TRW site is located on glacial till that is over 100 feet thick and contains a productive aquifer. The surface soil is chile silt loam, and the till becomes increasingly gravelly with depth. The glacial till in this area is underlain by a limestone-shale bedrock. General details of the area geology and hydrology were presented in the June report (Clement 1983a). Additional site-specific geologic and hydrogeologic information was also developed as part of this study and is provided in later sections of this report.

b. The Nature and Extent of the Groundwater Problem

Although the existence in surface soils of PCBs and volatile organics has been investigated at the TRW site and reported previously (Clement 1983a, 1983b, 1984a, and 1984b), groundwater contamination at the site has been shown to consist primarily of volatile organics. Preliminary groundwater investigations have been ongoing as part of the earlier surface and soil investigations conducted at the site (Clement 1983a, 1983b, 1984a).

Before initiation of the current groundwater investigation, 22 monitoring wells had already been installed at the site, and water level measurements and chemical analyses of groundwater (including analysis of PCBs, volatile organics, pH, specific conductance, and TOX) have been performed periodically for several years. Results of these earlier studies are documented in the earlier reports (Clement 1983a, 1983b, 1984a) and discussed later in this report.

Data from the earlier groundwater studies indicate that PCB contamination in groundwater is not currently a significant concern and proposed surface remediation should preclude further significant PCB migration, but that quantities of several volatile organics detected in groundwater warrant additional study. Currently only one of the 22 monitoring wells consistently exhibit PCB concentrations exceeding the limit of detection by a significant margin. PCB concentrations in this well have ranged from 100 parts per trillion (ppt) to 1 part per billion (ppb) and average 300 ppt. A risk assessment conducted to evaluate potential exposure due to the current concentrations of PCBs in groundwater shows that these quantities pose an insignificant potential risk (Clement 1983a).

Volatile organics were discovered in groundwater at the TRW site in the spring of 1984. An investigation was initiated at that time to assess the extent and distribution of volatile organics at the site, evaluate the potential for off-site movement, determine the effects of potential interactions between

PCBs and volatile organics, assess the potential health and environmental effects posed by the presence of these volatile organics, and assist in identifying and selecting appropriate remedial measures.

During this investigation (conducted in June and July of 1984), concentrations of 1,1,1-trichloroethane (TCA) and traces of trichloroethene (TCE) were detected in wax ditch residues, South Pond sediments, and a localized hot spot in the rubble pile. In addition, TCE, 1,1-dichloroethane, trans-1,2-dichloroethene, and lower concentrations of TCA, 1,2-dichloroethane, 1,1-dichloroethane, and traces of several other compounds were detected in groundwater samples collected from monitoring wells at the site. Details of this study are provided in the report submitted to USEPA and OEPA in August 1984 (Clement 1984a).

Volatile organics were used at the TRW site and were introduced into the environment as a consequence of materials handling; this site has never formally been used to dispose of hazardous wastes. The TRW plant houses a metal casting operation in which volatile organics (specifically, trichloroethene before 1972 and 1,1,1-trichloroethane since 1972) were used in degreasers. Spent degreasing materials were discharged directly to the wax ditch and subsequently flowed into the South Pond. Dredged material from the South Pond and wax ditch were also deposited on the rubble pile.

The risk assessment conducted as part of this investigation indicated that both the potential for migration of volatile

organics from soil matrices on the site and the continued migration of volatile organics already present in the groundwater could potentially pose a risk to human health or the environment and, therefore, needed to be addressed as part of an overall site remediation plan (for details, see Clement 1984a). The migration pathways for volatile organics considered as part of this risk assessment include volatilization and percolation to groundwater. The potential receptors include site workers, residents living downwind of the site, and local users of groundwater and surface water. The principal pathway of concern identified in this study was the percolation to groundwater and subsequent movement within the groundwater to potential receptors (through drinking water wells or surface streams).

The remedial alternatives identified as being potentially appropriate for addressing the problem of possible volatile organic migration from the TRW site indicated that a two-track approach would expedite the solution. The decision was therefore made to treat the surface problem and the groundwater problem separately. A plan for surface remediation was finalized and presented to USEPA in December 1984 (Clement 1984b). The groundwater problem was determined to require more extensive study before an appropriate remediation plan could be finalized. This report presents the results of that study.

c. Site History

A history of the site, including site investigations, cleanups, and other responses to the discovery of volatile organics on site, is summarized in the following chronology.

08/07/81	OEPA and USEPA notified by TRW that PCBs discovered on property
08/10/81	Telephone conversations to assess severity of problem
08/18/81	Mark Torf (OEPA) visited site and collected oil and sediment samples (samples split with TRW)
08/21/81	TRW made a presentation on status of site at West Lake, Ohio, office of USEPA
08/22/81	USEPA staff visited site and collected soil, oil, wax, and sewer water samples (samples split with TRW)
08/25/81	Wax ditch oil slick removed by Emergency Response and Environmental Restoration of New Jersey; waste sent to a secure landfill
08/27/81	USEPA staff conducted a PCB-TSCA (Toxic Substances Control Act) inspection of the site
08/81	OEPA staff tested local private wells for PCBs
09/01/81	TRW retained Clement Associates to assist in investigating the problem
09/14/81	USEPA staff visited site and sample production wells and well at TRW barn (samples split with TRW)
12/21/81	Initial field investigation by Clement initiated
02/04/82	Installation of 18 monitoring wells initiated
05/14/82	TRW provided status report to OEPA by letter
05/19/82	TRW presented status of site to OEPA at TRW
07/06/82	Groundwater monitoring initiated at the site
08/26/82	USEPA staff visited site and collect water samples from barn, production wells, and sanitary sewer (samples split with TRW)
09/09/82	Comprehensive soil and sediment sampling initiated
10/25/82	Four additional monitoring wells installed on the South Property
06/20/83	TRW presented conclusions of PCB investigation to USEPA and OEPA in Chicago

07/10/83	TRW retained O'Brien and Gere to assist in the design of remediation
12/20/83	TRW presented a surface remediation plan to immobilize PCBs at the site to USEPA and OEPA in Chicago
02/21/84	TRW presented status of site to OEPA in Columbus
03/20/84	OEPA performed RCRA (Resource Conservation and Recovery Act) inspection of site
06/84	Volatile organics discovered in groundwater at TRW site
07/11/84	Volatile organic field investigation commenced
08/29/84	TRW presented a revised remediation plan to OEPA in Columbus and proposed the feasibility studies required to implement the plan
09/15/84	Groundwater feasibility study initiated
09/15/84	Surface remediation feasibility study initiated
09/84-3/85	Ten additional groundwater monitoring wells installed and sampled
09/84-11/84	Residential wells southwest of site sampled
11/84	Surface Remediation Feasibility Study completed
12/7/84	Surface Remediation Plan finalized and presented to USEPA

Task 2. Investigation Support

A work plan for the groundwater feasibility study was developed and presented to USEPA in the fall of 1984. The work was subsequently conducted in phases so that the results of earlier tasks could be used to adjust and modify procedures for later tasks, making the process more efficient. Thus several modifications to the initial work plan were ultimately incorporated into an amended work plan (Appendix 1 to this document). During the development of the work plan, available site data

were evaluated to determine the objectives of the investigation to be conducted, the overall design of the investigation (including boundary conditions and the establishment of site security), and quality control/quality assurance and health and safety considerations. Quality control/quality assurance measures are discussed under Task 6 of this report. The other items listed above are discussed below.

a. Health and Safety Plans

Although health and safety plans were not documented directly in the amended work plan, such considerations were included in the overall planning and incorporated into work procedures. Accordingly, details of health and safety considerations were presented in attachments C and D of the drilling contract for the field work conducted. They are provided in Appendix 3 to this report.

In general, health and safety plans for the site required that the following protective gear be worn by field investigators in contaminated areas at all times:

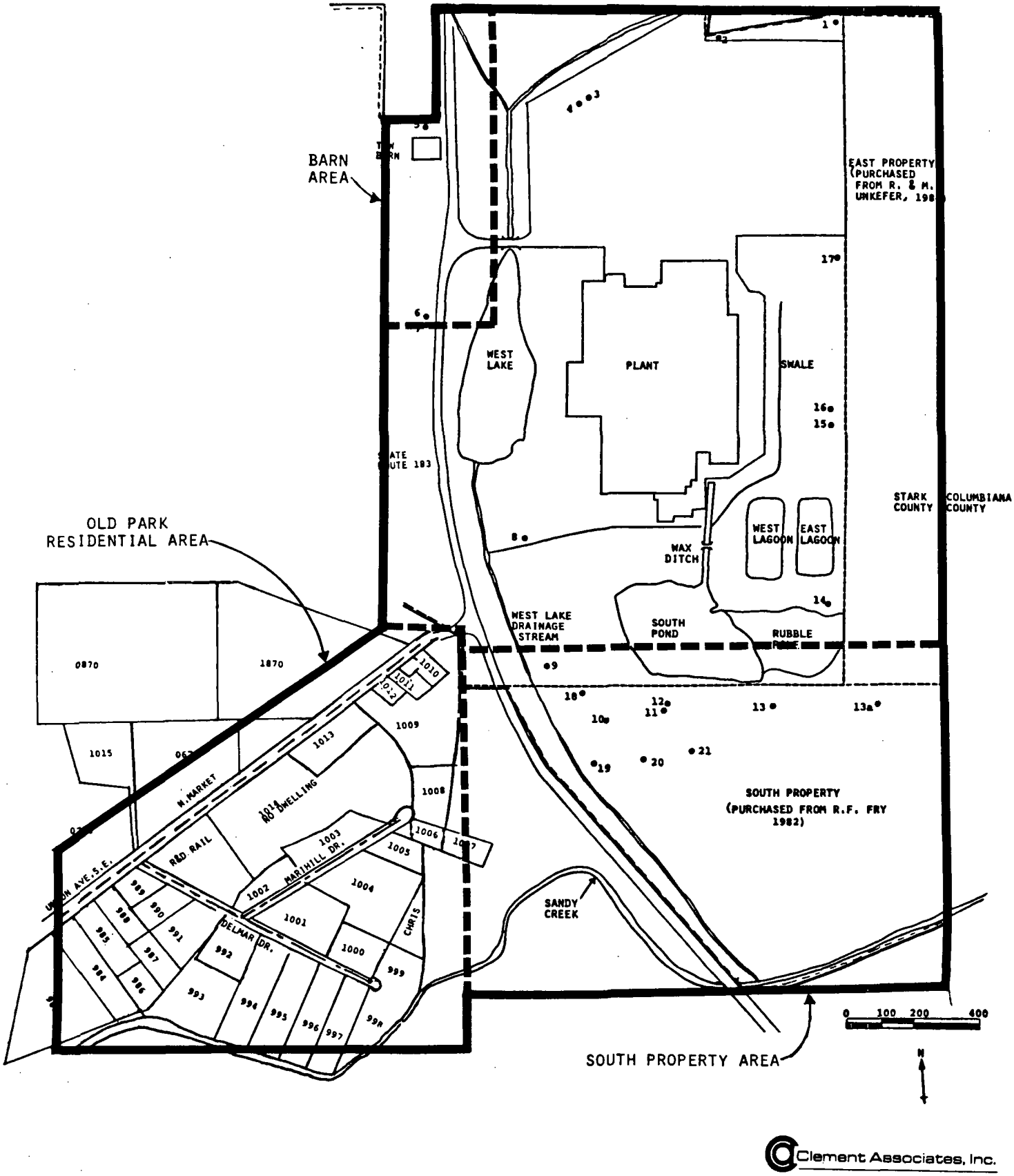
- Tyvek suits (disposable)
- Neoprene rubber gloves (disposable)
- Rubber boots (disposable)

b. Boundary Conditions

The boundaries for the area of focus of the groundwater remedial investigation are depicted in Figure 3. The investigation included the area south of the plant to Sandy Creek, the

FIGURE 3

BOUNDARY CONDITIONS : AREA OF FOCUS FOR GROUNDWATER INVESTIGATION AT THE TRW SITE, MINERVA, OHIO



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area near the barn northwest of the facility, and the Old Park residential area southwest of the facility. These areas represent the locations where volatile organics have been detected and, in the case of the residential area, where a significant impact of volatile organic contamination might occur.

c. Site Map

A detailed topographic survey of the site is included in Appendix 2. The survey map shows all prominent features of the site including the locations of all monitoring wells.

d. Preinvestigation Evaluation

Prior to development of the work plan for the remedial investigation at the site it was clear that the problem centered around contamination of groundwater with volatile organics (as indicated in the discussion of the problem in Task 1). A generally accepted and feasible remedial alternative for such a situation is withdrawal of contaminated groundwater and treatment by one of several alternatives. Based on previous knowledge of the site, including such factors as high soil permeability and depth to bedrock, it was concluded that groundwater withdrawal and treatment would be the principal remedial action to consider, should a remedial action be required. The remedial investigation work plan was therefore formulated to provide sufficient information to evaluate and design such a system. Groundwater sampling, depth measurements, a pump test and groundwater modeling were therefore included in the remedial investigation.

Task 3. Remedial Investigation Work Plan

The detailed work plan developed before the initiation of the field investigation (presented in Appendix 1) outlined the following areas of investigation which are discussed in detail below:

- Residential well sampling
- Sandy Creek sampling
- Priority pollutant investigation
- Initial monitoring well investigation
- Supplemental monitoring well investigation
- Site survey
- Pump test
- Groundwater flow modeling

The objectives of the work plan and remedial investigation were to determine the full extent of the groundwater contamination in terms of areal extent, depth of contaminants and potential movement of contaminants. The investigation was also designed to provide sufficient information on the hydrology of the site, so that a remedial action could be designed. Information from previous studies was also used in analyzing the data from this investigation. Such studies are referenced as appropriate.

Sampling of residential wells. A total of twenty private residential wells were sampled in the Old Park residential area southwest of the TRW facility. Samples were taken on three occasions: September 11, 1984, November 1-6, 1984, and

December 5, 1984. Six wells were sampled twice and seven wells were sampled three times in order to confirm results. Sample locations are shown in Figure 4. Samples were collected from taps inside the houses, as wells were not accessible. Samples were analyzed for volatile organics, pH, specific conductance and total organic halogen (TOX).

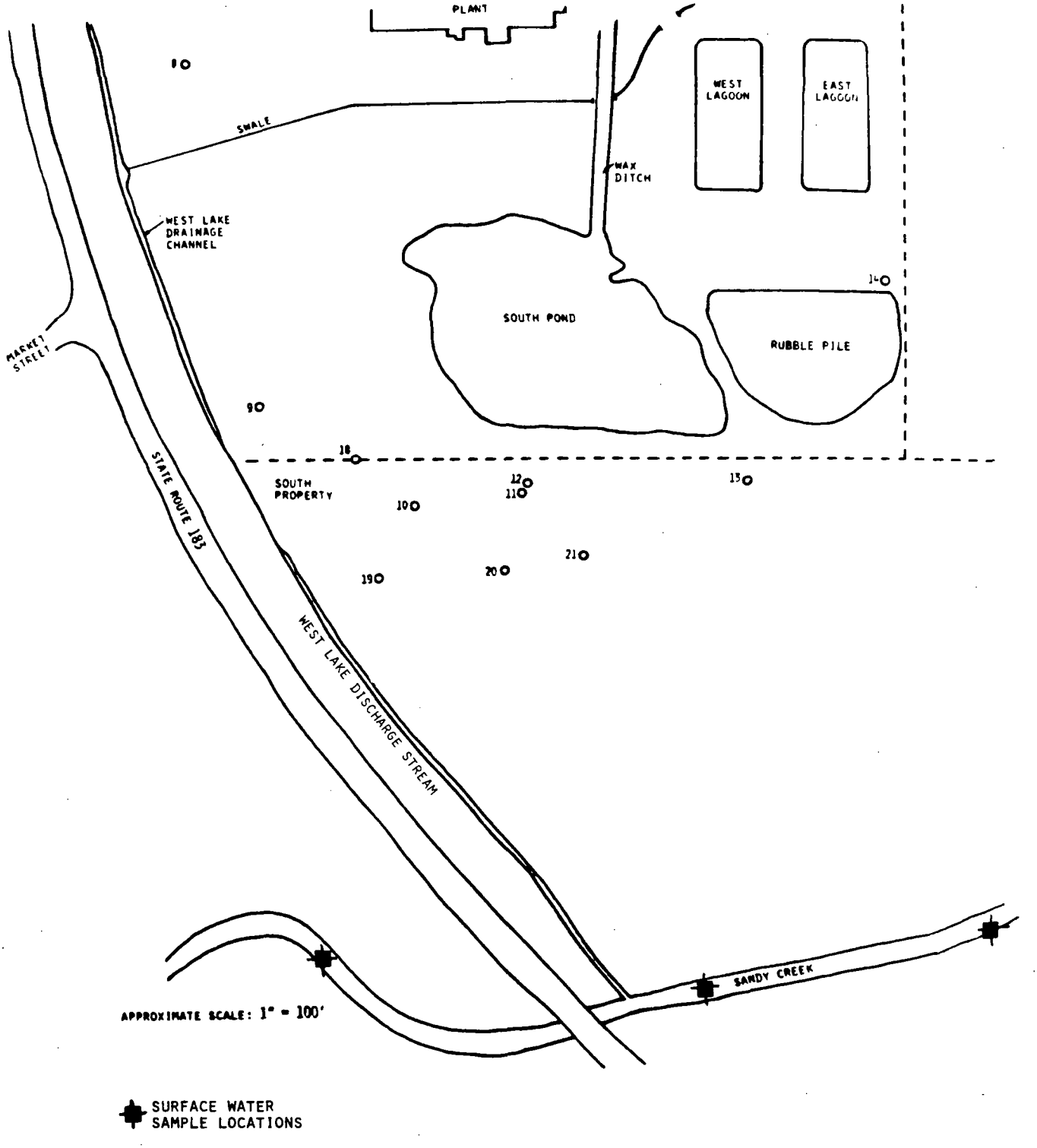
Sampling of Sandy Creek. To determine if the on-site contamination had affected Sandy Creek, three surface water samples were collected from locations believed to be downgradient of the site. Sample locations are shown in Figure 5. Samples were collected during dry periods (i.e., at least 3 days after any rainfall) in order to prevent interference from sediment. The samples were analyzed for volatile organics. Because the contaminants in question are volatile and are not generally adsorbed onto sediment; and because of the relatively rapid flow rate of Sandy Creek, contaminants were not expected to occur in sediments. Therefore no sediment analysis was performed.

Investigation for priority pollutants. Samples from representative monitoring wells at the TRW site were subjected to a priority pollutant scan to confirm that all major groundwater contaminants had been detected. Wells 1, 10, 13 and 19 were selected for this investigation because they had exhibited the highest levels of volatile organic contamination. (Well No. 1 served as an upgradient control.) Figure 6 shows the location of the monitoring wells sampled.

non responsive

FIGURE 5

LOCATIONS FOR SANDY CREEK SAMPLES AT THE TRW SITE IN MINERVA, OHIO



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Investigation of initial monitoring wells. Selected initial (or existing) wells were sampled on five occasions during the remedial investigation to determine the lateral extent of contamination. Wells No. 1, 10, 11, 12, 13, 18, 19, 20 and 21 (Figure 6) were sampled and analyzed for volatile organics, pH, specific conductance and TOX. Samples were collected in October and November, 1984, January 1985 and twice in February 1985.

Investigation of supplemental monitoring wells. In order to further delineate the areal and vertical extent of contamination, a series of supplemental wells was installed. Two types of wells were installed: multi-wells and single wells. The multi-wells (22m, 23m, and 4m, see Figure 6) were installed such that soil and water samples could be taken at 13-foot intervals during the drilling. Wells 22m and W4m were sunk to bedrock. The final well screens were then set based on results of the sample analyses. Well W4m was placed in order to determine the source and extent of contamination found in a production well in the TRW barn. Based on the results of samples taken from the multi-wells it was decided to install seven additional single wells. Five of these wells--Wls, W2s, W3s, W4s, 24s--were installed downgradient of the contaminated areas and were screened in the upper 20 feet of the water table. Wells W5s and W6s were installed (also in the upper 20 feet of the water table) in order to further delineate the contamination in the barn area. The supplemental wells were sampled twice within a 2-week period in February 1985 and analyzed

for volatile organics, pH, specific conductance and TOX. Two additional wells were also installed in the Old Park residential area. Those wells were used only for water level measurements and were not sampled.

Site survey. The completed survey is provided in Appendix 2 and includes all major topological features of the site and the elevations and locations of all monitoring wells installed as part of the overall investigation.

Pump test. An 8-inch test well (TW1, Figure 6) was installed in order to perform a pump test. Water was pumped from the test well at 320 gallons per minute (gpm) for approximately 24 hours. The aquifer was then allowed to recover for another eight hours. During the test, water levels were monitored in Wells 9, 10, 11, 12, 18, 19, 20, 21, 22m, 23m, W1s, W2s, W3s, and W4s. This information was obtained in order to determine the permeability and transmissivity of the soils, and to aid in designing a well withdrawal field.

Groundwater flow modeling. A USGS three-dimensional flow model was used for the groundwater flow modeling. The purpose of the modeling was to simulate steady state groundwater conditions and to conduct simulation studies for determining the most efficient placement of the withdrawal wells to remove contaminated groundwater.

Other considerations. Since this investigation focused on groundwater (and incorporated the above-listed work components) several of the subtasks listed under task 3 in the GSOW are not

relevant to this document but were considered as part of the wider site investigation and are detailed elsewhere. Therefore appropriate references are provided below.

a. Waste Characterization

This report deals with volatile organics in groundwater. Characterization of site "wastes" was presented as part of the surface remediation plan (Clement 1984b).

b. Hydrogeologic Investigation

As indicated above, this groundwater investigation was conducted in eight steps or tasks. The objectives of the program were to determine the nature and extent of groundwater contamination, the characteristics of the local aquifer and other subsurface geologic features, the direction and charateristics of local groundwater flow, the vertical and horizontal distribution of groundwater contamination, background levels of contamination, and the relative mobility of local contaminants. Local potential receptors were also identified as part of this study as well as potential remedial alternatives for preventing further contaminant movement. Details of the plan are provided in Appendix 1.

c. Soils Investigation

An extensive soils investigation was conducted and reported previously (see Clement 1983a, 1983b, 1984a, 1984b).

d. Surface Water and Sediment Investigation

Extensive surface water and sediment sampling was conducted and reported previously (see Clement 1983a, 1983b, 1984a, and 1984b). Additional surface water was also conducted in this study as part of an attempt to determine potential impacts of groundwater contamination (see Appendix 1). Results are presented in later sections of this report.

e. Air Investigation

Consideration of potential air contamination was incorporated into earlier studies (see Clement 1983a, 1983b, 1984a, and 1984b).

Task 4. Remedial Investigation Analysis

a. Data Analysis

Sampling of residential wells. Results of the residential well sampling are summarized in Table 1. Seven of the 20 wells exhibited chloroethene in concentrations ranging from 2 to 16 ppb. Two wells showed trace levels (between 1 and 3 ppb) of three other VOCs: 1,1-dichloroethane (DCA), trans-1,2-dichloroethene (DCE), and 1,1,1-trichloroethane (TCA). Three additional wells showed trace levels of DCE and DCA in addition to vinyl chloride in concentrations from 2 to 12 ppb. Eight of the 20 wells sampled showed no contamination.

It should be noted that houses in the Old Park area are being connected to the Minerva city water system. These connections were planned prior to the remedial investigation because

TABLE 1

SUMMARY OF RESIDENTIAL WELL ANALYSIS
RESULTS FOR THE TRW SITE IN MINERVA, OHIO

Well[a]	Compounds Detected	Concentrations (ppb) Detected on Date Sampled[b]			
		9/11/84	11/1/84	11/6/84	12/5/84
1	(Not Sampled)				
2	(Not Sampled)				
3		ND			
4	1,1,-Dichloroethane			1	
	Trans-1,2-dichloroethene			2	
5	(Not Sampled)				
6		ND		ND	ND
7		ND			ND
8				ND	
9		ND		ND	ND
10A	1,1-Dichloroethane			2	1
	1,1,1-Trichloroethane			2	2
10B	1,1-Dichloroethane			2	
	1,1,1-Trichloroethane			2	
11	(Not Sampled)				
12	Chloroethene		2		2
13A					
13B	Chloroethene	ND	2		2
14A					
14B	Chloroethene	ND		8	13
15A	Chloroethene	ND		9	13
15B					
16A					
16B	Chloroethene		11		16
17A	Chloroethene	ND	2		9
17B	Chloroethene		2		

TABLE 1 (continued)

Well[a]	Compounds Detected	Concentrations (ppb) Detected on Date Sampled[b] 9/11/84	11/1/84	11/6/84	12/5/84
18		ND			
19A	Trans-1,2-dichloroethene	1	ND		ND
	Chloroethene	ND	2		3
19B					
20	Chloroethene		7		15
21	Trans-1,2-dichloroethene	2	1		ND[c]
	1,1-Dichloroethane	1	1		ND[c]
	Chloroethene	ND	8		ND[c]
22	(Not sampled)				
23	1,1-Dichloroethane	3	2		
	Trans-1,2-dichloroethene	3	2		
	Chloroethene	ND	12		
24	(Not sampled)				
25	(Not sampled)				
26		ND	ND		
27					ND

[a]If a single well serves two or more residences, it is indicated by a common well number with an "A" or "B". In some cases "duplicate" samples were obtained from the same well through each residence. Agreement in results from such duplicate analyses are excellent.

[b]"ND" means not detected. Otherwise only positive results are presented (i.e., volatile organics not detected in any of the analyses from a specific well are not listed).

[c]The house associated with well 21 was connected to the city water system prior to the December 5, 1984 sampling. The tap water sample taken from this home on December 5, 1984 therefore represents city water rather than well water.

See Appendix 4 for owner and location of the wells listed.

of the high iron content of the water. An assessment of potential health effects due to the volatile organics detected indicated that there was no immediate health hazard to users of groundwater in the area, although the chloroethene concentrations exhibited in some wells were high enough that long-term use of this water was not recommended. The scope of the health assessment conducted was summarized in a letter to the Stark County Health Department dated January 18, 1985 and a copy is provided in Appendix 5. It should be noted that residents in the area have been apprised of developments in a timely manner. As will be discussed later, there does not appear to be a direct association between contamination detected in the Old Park Area and volatile organics detected in groundwater at the TRW site.

Sandy Creek sampling. No volatile organics were detected in the three samples taken from Sandy Creek. As will be discussed later, groundwater contamination at the site is believed to have reached Sandy Creek. However, samples collected from Sandy Creek, including one collected where contaminated groundwater recharge is expected to be occurring, were all free of volatile organics. This is likely due to a combination of significant dilution within the creek and volatilization from the creek.

Priority pollutant investigation. The priority pollutant analysis did not reveal any organic contaminants other than the volatile organics previously detected. Lead was detected

in well 19 at 0.08 ppm (versus the federal drinking water standard of 0.05 ppm) and arsenic was detected in well 10 at the drinking water standard of 0.05 ppm. Zinc, copper, phenol and cyanide were also detected at levels below federal drinking water standards. Analysis results are provided in Appendix 6. These results are not inconsistent with background groundwater quality in the area (note results from the upgradient well 1). Based on these results, volatile organics are considered to represent the complete scope of contaminants in groundwater at the site except in the immediate vicinity of South Pond where traces of PCBs have also been detected (Clement 1983a). Accordingly, the selection of a remedial alternative was limited to those alternatives appropriate for control of volatile organics.

Investigation of initial monitoring wells. Results of the investigations of the initial monitoring wells are summarized in Table 2 along with volatile organic analyses of local groundwater from earlier studies. The contaminants found were chlorinated ethanes and ethenes; primarily trans-1,2-dichloroethene (DCE), trichloroethene (TCE) and 1,1-dichloroethane (DCA). Concentrations range from less than 10 parts per billion (ppb) to 2,000 ppb (10 ppb represents the detection limit in this study). Chloroethene was also detected in wells 11, 13, 19, 20 and 21 at concentrations from less than 10 ppb to 310 ppb. Results in Table 2 also indicate that, in general, the results of the sampling are consistent over time with respect to the types of contaminants found and their concentrations. One

TABLE 2

RESULTS OF VOLATILE ORGANIC ANALYSIS
OF GROUNDWATER SAMPLES FROM THE INITIAL MONITORING WELLS

(Concentrations in ppb)

Well No. 1

	Sampling Date								
Compound	a	b	c	d[2]	e[5]	f	g	h	i
1,1,1-Trichloroethane	NS	-	-	-	-	-	-	-	-
1,1-Dichloroethane	NS	-	-	-	-	-	-	-	-
1,2-Dichloroethane	NS	-	-	-	-	-	-	-	-
Chloroethane	NS	-	-	-	-	-	-	-	-
Trichloroethene	NS	-	-	-	-	-	-	-	-
1,1-Dichloroethene	NS	-	-	-	-	-	-	-	-
Trans-1,2-dichloro-ethene	NS	-	-	-	-	-	-	-	-
Chloroethene	NS	-	-	-	-	-	-	-	-
2-Propanone	NS	-	-	-	-	-	-	-	-

Well No. 2

	Sampling Date								
Compound	a	b	c	d	e	f	g	h	i
1,1,1-Trichloroethane	-	-	NS	NS	NS	NS	NS	NS	NS
1,1-Dichloroethane	-	-	NS	NS	NS	NS	NS	NS	NS
1,2-Dichloroethane	-	-	NS	NS	NS	NS	NS	NS	NS
Chloroethane	-	-	NS	NS	NS	NS	NS	NS	NS
Trichloroethene	-	-	NS	NS	NS	NS	NS	NS	NS
1,1-Dichloroethene	-	-	NS	NS	NS	NS	NS	NS	NS
Trans-1,2-dichloro-ethene	-	-	NS	NS	NS	NS	NS	NS	NS
Chloroethene	-	-	NS	NS	NS	NS	NS	NS	NS
2-Propanone	-	-	NS	NS	NS	NS	NS	NS	NS

Well No. 8

Compound	Sampling Date a	b	c	d	e	f	g	h	i
1,1,1-Trichloroethane	NS	-	NS	NS	NS	NS	NS	NS	NS
1,1-Dichloroethane	NS	-	NS	NS	NS	NS	NS	NS	NS
1,2-Dichloroethane	NS	-	NS	NS	NS	NS	NS	NS	NS
Chloroethane	NS	-	NS	NS	NS	NS	NS	NS	NS
Trichloroethene	NS	-	NS	NS	NS	NS	NS	NS	NS
1,1-Dichloroethene	NS	-	NS	NS	NS	NS	NS	NS	NS
Trans-1,2-dichloro-ethene	NS	-	NS	NS	NS	NS	NS	NS	NS
Chloroethene	NS	-	NS	NS	NS	NS	NS	NS	NS
2-Propanone	NS	-	NS	NS	NS	NS	NS	NS	NS

Well No. 9

Compound	Sampling Date a	b	c	d	e	f	g	h	i
1,1,1-Trichloroethane	NS	30	26	18	NS	NS	NS	NS	NS
1,1-Dichloroethane	NS	22	17	17	NS	NS	NS	NS	NS
1,2-Dichloroethane	NS	-	-	-	NS	NS	NS	NS	NS
Chloroethane	NS	-	-	-	NS	NS	NS	NS	NS
Trichloroethene	NS	-	-	-	NS	NS	NS	NS	NS
1,1-Dichloroethene	NS	-	-	-	NS	NS	NS	NS	NS
Trans-1,2-dichloro-ethene	NS	-	-	-	NS	NS	NS	NS	NS
Chloroethene	NS	-	-	-	NS	NS	NS	NS	NS
2-Propanone	NS	-	-	-	NS	NS	NS	NS	NS

Well No. 10

Compound	Sampling Date a	b[3]	c[3]	d[2,3,4]	e	f	g	h	i
1,1,1-Trichloroethane	-	11	-	-	-	-	-	-	-
1,1-Dichloroethane	47	200	260	290	280	170	210	350	270
1,2-Dichloroethane	-	-	-	-	-	-	-	-	-
Chloroethane	-	-	-	-	-	-	-	-	-
Trichloroethene	39	120	100	140	250	100	150	130	160
1,1-Dichloroethene	-	-	-	18	-	-	-	-	-
Trans-1,2-dichloro-ethene	120	320	350	500	530	180	300	370	360
Chloroethene	-	-	-	-	52	-	-	-	-
2-Propanone	-	-	-	-	-	-	-	-	-

Well No. 11

Compound	Sampling Date a	b	c	d	e	f	g	h	i
1,1,1-Trichloroethane	NS	-	-	-	NS	NS	-	-	-
1,1-Dichloroethane	NS	26	63	71	NS	NS	79	130	94
1,2-Dichloroethane	NS	-	-	-	NS	NS	T	-	-
Chloroethane	NS	-	-	-	NS	NS	-	-	-
Trichloroethene	NS	12	18	23	NS	NS	28	28	37
1,1-Dichloroethene	NS	-	-	-	NS	NS	-	-	-
Trans-1,2-dichloro-ethene	NS	45	96	150	NS	NS	110	160	130
Chloroethene	NS	-	26	-	NS	NS	-	-	-
2-Propanone	NS	T	49	-	NS	NS	-	-	-

Well No. 12

Compound	Sampling Date a	b	c	d[2]	e	f	g	h	i
1,1,1-Trichloroethane	-	-	-	-	NS	NS	-	-	-
1,1-Dichloroethane	-	-	T	-	NS	NS	-	T	-
1,2-Dichloroethane	-	-	-	-	NS	NS	-	-	-
Chloroethane	-	-	-	-	NS	NS	-	-	-
Trichloroethene	-	-	-	-	NS	NS	-	-	-
1,1-Dichloroethene	-	-	-	T[3]	NS	NS	-	-	-
Trans-1,2-dichloroethene	-	10	114	T[3]	NS	NS	-	T	-
Chloroethene	-	-	-	-	NS	NS	-	-	-
2-Propanone	-	-	-	-	NS	NS	-	-	-

Well No. 13

Compound	Sampling Date a	b	c	d[2]	e	f	g	h	i
1,1,1-Trichloroethane	-	NS	12	T	T	-	NS	-	-
1,1-Dichloroethane	-	NS	530	330	1600	310	NS	1900	2000
1,2-Dichloroethane	-	NS	-	-	T	-	NS	-	-
Chloroethane	-	NS	58	43	-	17	NS	560	610
Trichloroethene	-	NS	18	T	T	-	NS	-	-
1,1-Dichloroethene	-	NS	-	-	-	-	NS	-	-
Trans-1,2-dichloroethene	-	NS	120	-	490	110	NS	590	640
Chloroethene	-	NS	-	-	150	-	NS	235	310
2-Propanone	X	NS	-	-	-	-	NS	-	-

Well No. 14

Compound	Sampling Date a	b	c	d	e	f	g	h	i
1,1,1-Trichloroethane	-	NS	-	T	NS	NS	NS	NS	NS
1,1-Dichloroethane	-	NS	-	-	NS	NS	NS	NS	NS
1,2-Dichloroethane	-	NS	-	-	NS	NS	NS	NS	NS
Chloroethane	-	NS	-	-	NS	NS	NS	NS	NS
Trichloroethene	-	NS	15	11	NS	NS	NS	NS	NS
1,1-Dichloroethene	-	NS	-	-	NS	NS	NS	NS	NS
Trans-1,2-dichloroethene	30	NS	14	18	NS	NS	NS	NS	NS
Chloroethene	-	NS	-	-	NS	NS	NS	NS	NS
2-Propanone	-	NS	-	-	NS	NS	NS	NS	NS

Well No. 18

Compound	Sampling Date a	b	c	d	e	f	g	h	i
1,1,1-Trichloroethane	NS	T	-	-	NS	NS	NS	-	NS
1,1-Dichloroethane	NS	108	120	92	NS	NS	NS	790	NS
1,2-Dichloroethane	NS	T	-	-	NS	NS	NS	-	NS
Chloroethane	NS	110	250	270	NS	NS	NS	1700	NS
Trichloroethene	NS	T	-	-	NS	NS	NS	140	NS
1,1-Dichloroethene	NS	-	-	-	NS	NS	NS	-	NS
Trans-1,2-dichloroethene	NS	11	-	12	NS	NS	NS	570	NS
Chloroethene	NS	-	-	-	NS	NS	NS	-	NS
2-Propanone	NS	-	-	-	NS	NS	NS	-	NS

Well No. 19

Compound	Sampling Date a	b	c	d	e	f	g	h	i
1,1,1-Trichloroethane	-	T	-	-	-	-	-	-	-
1,1-Dichloroethane	12	1500	1200	1300	880	25	160	500	620
1,2-Dichloroethane	-	10	-	-	-	-	-	-	-
Chloroethane	-	-	-	-	-	-	-	-	-
Trichloroethene	13	1300	1300	1200	950	27	130	250	350
1,1-Dichloroethene	-	25	-	16	-	-	-	-	-
Trans-1,2-dichloro-ethene	32	910	690	1300	740	82	190	340	380
Chloroethene	-	91	-	110	190	110	-	-	-
2-Propanone	-	-	-	-	-	-	-	-	-

Well No. 20

Compound	Sampling Date a	b	c	d	e	f	g	h	i
1,1,1-Trichloroethane	NS	-	-	-	NS	NS	-	-	-
1,1-Dichloroethane	NS	-	-	-	NS	NS	-	-	-
1,2-Dichloroethane	NS	T	T	12	NS	NS	-	11	T
Chloroethane	NS	-	-	45	NS	NS	-	-	-
Trichloroethene	NS	-	-	-	NS	NS	-	-	-
1,1-Dichloroethene	NS	-	-	-	NS	NS	-	-	-
Trans-1,2-dichloro-ethene	NS	15	12	27	NS	NS	13	16	16
Chloroethene	NS	-	-	-	NS	NS	-	-	-
2-Propanone	NS	-	-	-	NS	NS	-	-	-

Well No. 21

Compound	Sampling Date								
	a	b	c	d[2]	e	f	g	h	i
1,1,1-Trichloroethane	NS	-	-	-	NS	NS	NS	-	-
1,1-Dichloroethane	NS	T	-	-	NS	NS	NS	-	-
1,2-Dichloroethane	NS	T	-	-	NS	NS	NS	-	-
Chloroethane	NS	-	-	-	NS	NS	NS	-	-
Trichloroethene	NS	T	-	-	NS	NS	NS	-	-
1,1-Dichloroethene	NS	T	-	-	NS	NS	NS	-	-
Trans-1,2-dichloro-ethene	NS	45	T	18	NS	NS	NS	23	17
Chloroethene	NS	-	-	-	NS	NS	NS	37	62
2-Propanone	NS	-	-	-	NS	NS	NS	-	-

[1]Although a complete volatile organic scan was performed on all samples listed, only positive results are presented in this table.
Compounds normally reported in a volatile organic scan but not listed in this table were not detected.

[2]Butyl acetate was detected. In well 12 the concentration of butyl acetate was sufficient to interfere with other analyses resulting in a detection limit of 500 ppb.

[3]Because of the concentrations of volatile organics detected in well 10, the limit of detection had to be raised to 50 ppb.

[4]In addition to the listed chemicals, tetrachloroethene was found at 48 ppb.

[5]Bis(2-ethylhexyl)phthalate detected at 90 ppb.

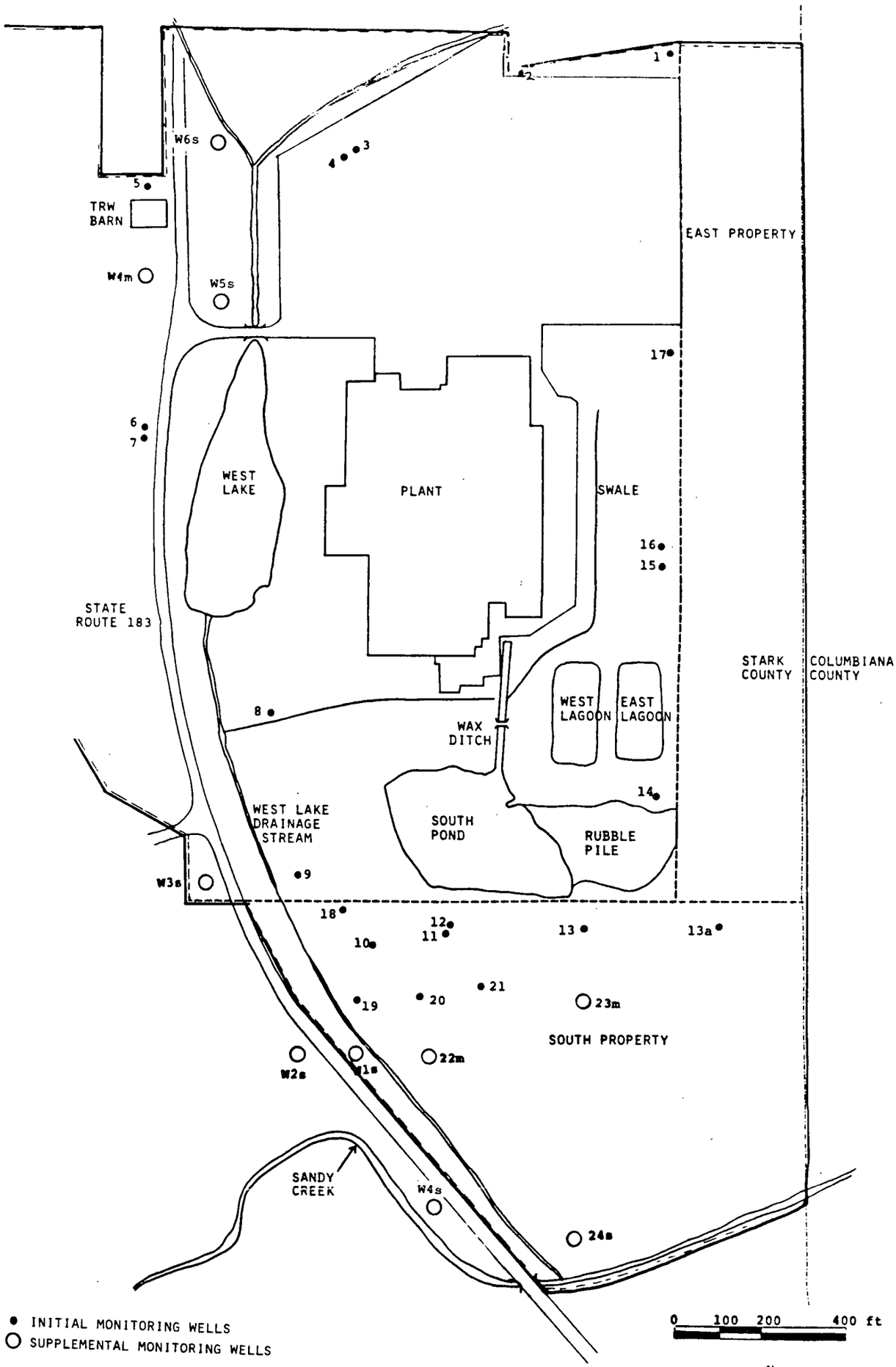
Key

- = Compound not detected
T = Trace compound detected at concentration below the stated 10 ppb detection limit
NS= Well not sampled on date indicated

Sampling dates: a=June 1, 1984; b=June 12, 1984; c=June 28, 1984; d=July 12, 1984; e=October 4, 1984; f=November 15, 1984; g=January 14, 1985; h=February 6-7, 1985; i=February 20-21, 1985

FIGURE 6

APPROXIMATE LOCATIONS OF MONITORING WELLS AT THE TRW SITE IN MINERVA, OHIO



● INITIAL MONITORING WELLS
○ SUPPLEMENTAL MONITORING WELLS

NOTE: EXACT LOCATIONS OF WELLS ARE SHOWN ON TOPOGRAPHIC SURVEY, APPENDIX 1

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exception to this is chloroethene which was detected irregularly in wells 10, 11, 13 and 19. This may be because of the difficulty in sampling and detecting chloroethene due to its extreme volatility. The most recent sampling from well 18 also appears to be abnormally high. Analyses of earlier samples from well 18 were therefore used in the data analysis. The implications of these initial tests results for exposure assessments and remedial alternatives are discussed below in connection with other sampling results.

Investigation of supplemental monitoring wells. The investigation of supplemental monitoring wells included analysis of soil and water samples from wells 22m, 23m and 4m, and additional groundwater samples from these wells, wells W1s-W6s and well 24s. Soil samples collected during boring were used both to determine the local geology and to investigate the extent of contaminant partitioning between soil and groundwater.

Two geologic cross sections of the site are presented in Figures 7 and 8. The locations of the cross sections are shown in Figure 9. These figures are based on the boring logs recorded during the drilling of the monitoring wells (and presented in Appendix 7). The cross sections show that below the topsoil the glacial till consists primarily of sand and gravel. In some areas (notably south of the site) traces of clay are interbedded with the sand. The normal water table occurs from 7 to 10 feet below the surface. The glacial till

FIGURE 7

GEOLOGIC CROSS SECTION A-A

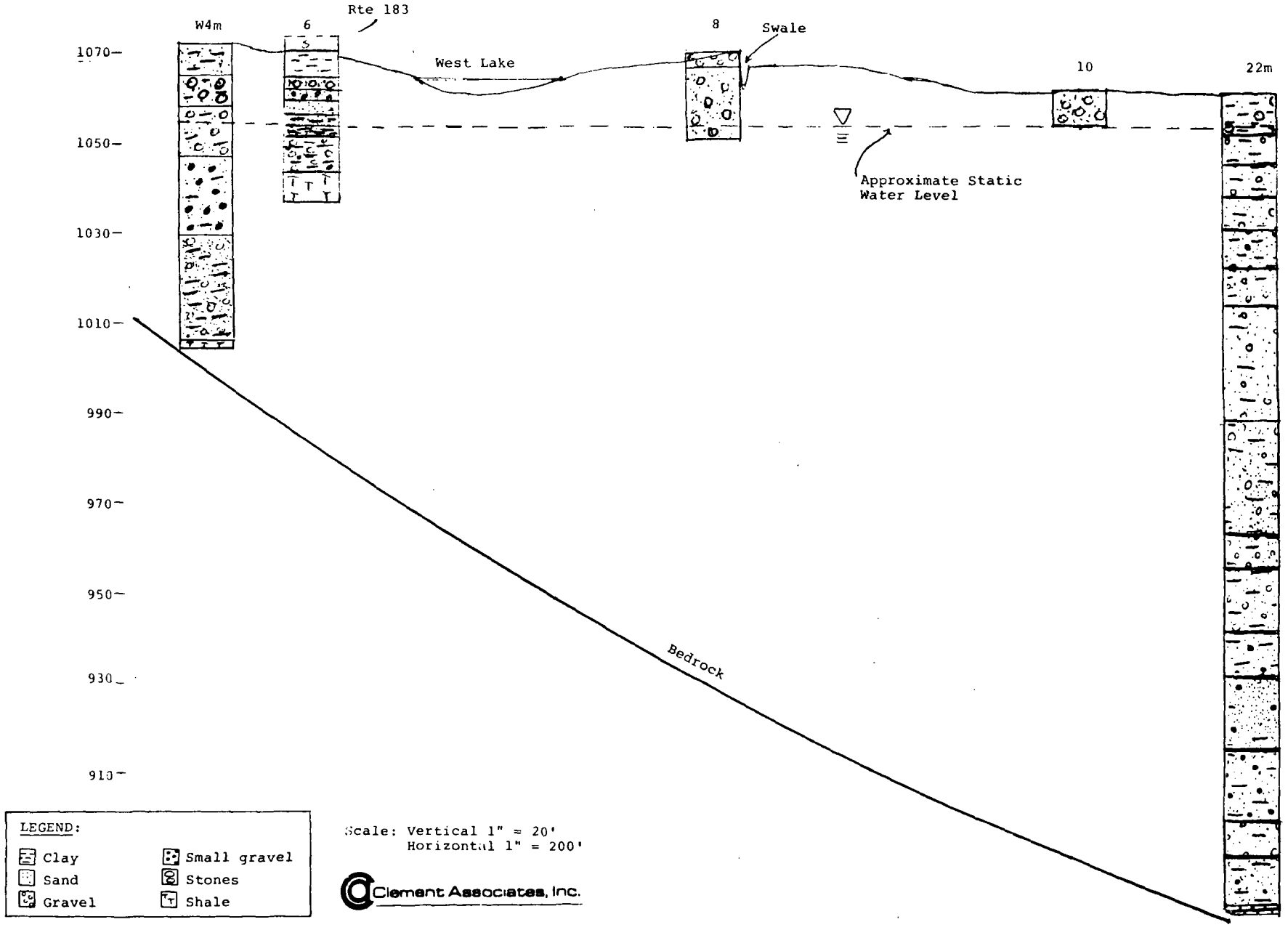

FIGURE 8

GEOLOGIC CROSS SECTION B-B

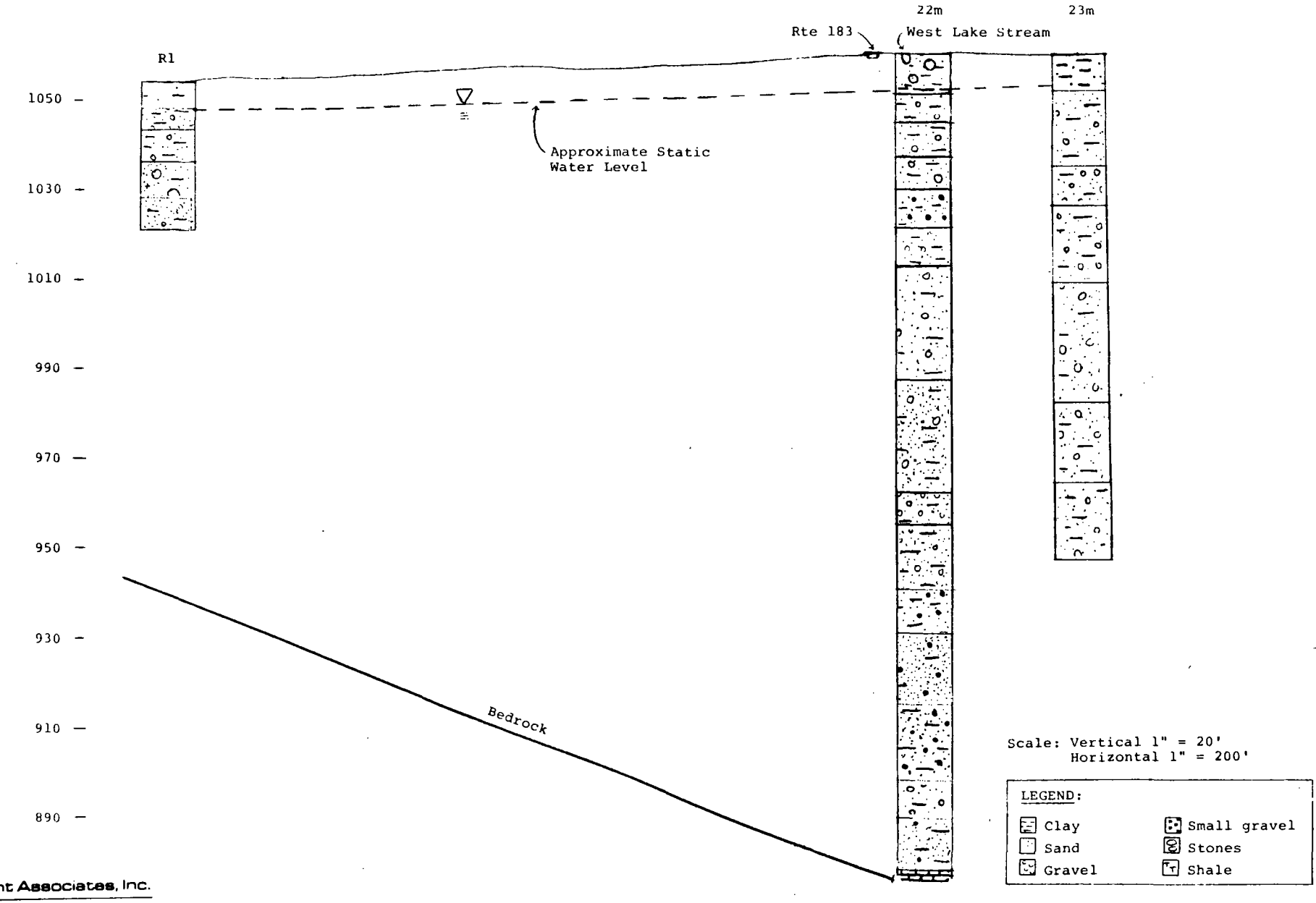

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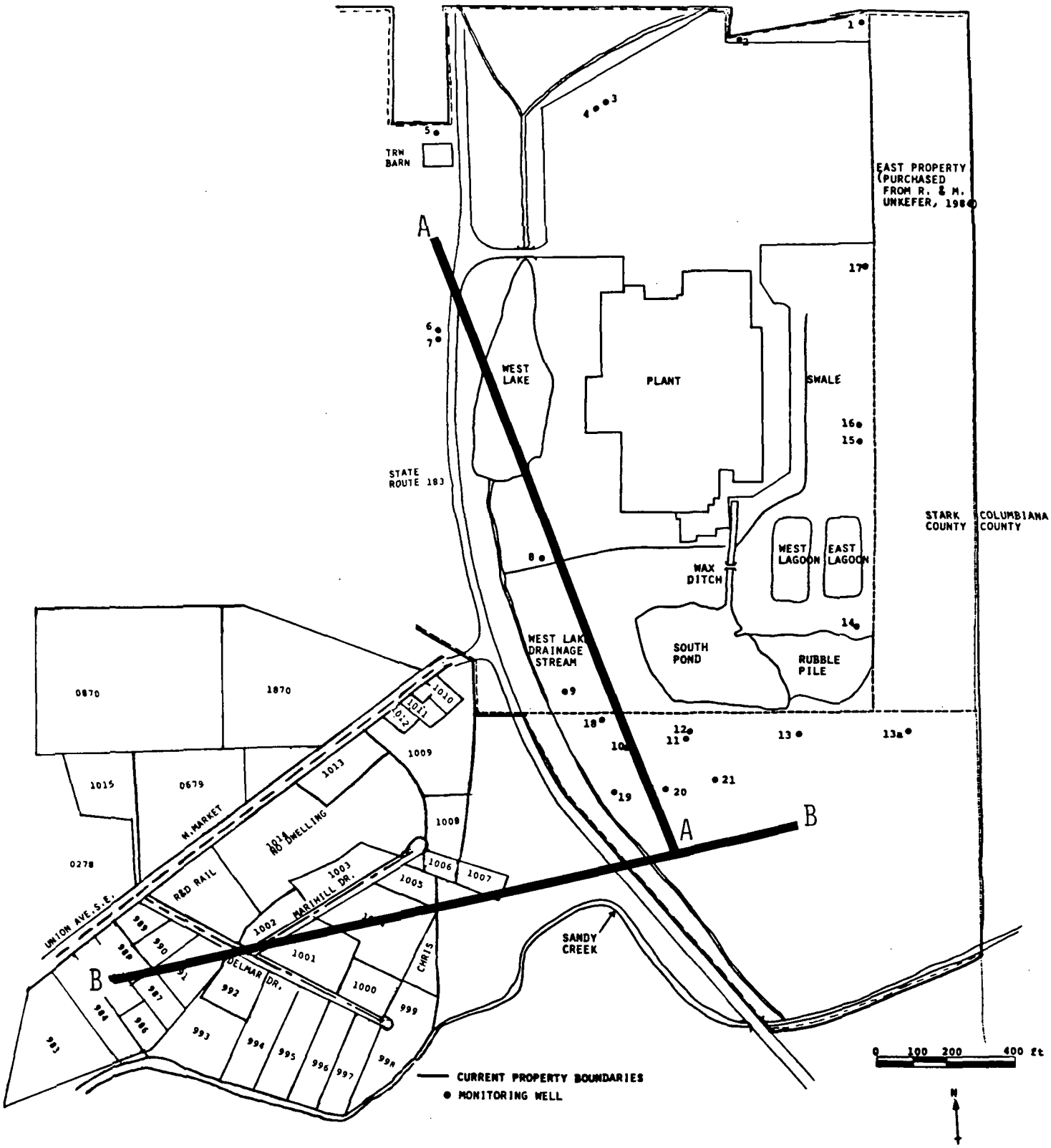
FIGURE 9

LOCATION OF GEOLOGIC CROSS SECTIONS TRW SITE, MINERVA, OHIO



is saturated to bedrock. Bedrock was reached in three of the borings drilled.

Based on the borings provided, the site lies on glacial till that is 150 feet deep on a north-south line bisecting the TRW plant and intersected by well 22m. The bedrock slopes upward to the west lying 54 feet below the surface at the TRW Barn and well W4m. Further west (and south) boring R3 reached bedrock at 14 feet.

Analysis of soil boring samples did not reveal significant contamination of volatile organics. Wells 23m and 4m showed no soil contamination. This suggests, as expected, that volatile organics do not adsorb strongly to soils.

Results of the groundwater sampling taken during drilling are presented in Table 3. Well 23m showed no contamination. Wells 22m and 4m showed contaminants only in the upper part of the groundwater. Based on these vertical groundwater profiles, it appears that contamination at the TRW site is confined to the upper 20 feet of aquifer and supplemental groundwater wells were screened accordingly.

Analyses of groundwater samples from all of the supplemental wells, collected after the boring was complete are presented in Table 4. Wells W2s, W6s and 24s showed no contamination. Wells Wls, W4s, and W5s showed levels of several contaminants ranging up to 541 ppb, and W3s showed levels of 1,1,1-TCA and 1,1-DCA ranging up to 28 ppb. Well 22m showed TCE and DCE

TABLE 3

RESULTS OF VOLATILE ORGANIC ANALYSIS OF GROUNDWATER SAMPLES FROM THE SUPPLEMENTAL MULTI-WELLS: SAMPLES TAKEN DURING DRILLING
(Concentration in ppb)

	Well Number 22M Depth of Sample (feet)				Well No. 23M Depth of Sample (feet)	Well 4M Depth of Sample (feet)		
Compound[1]	29-32	43-46	57-60	70-150[2]	5-92[3]	14-18	28-32	53
1,1,1-Trichloroethane	--	--	--	--	--	840	180	--
1,1-Dichloroethane	--	--	--	--	--	28	290	14
Tetrachloroethane	--	--	--	--	--	59	--	--
Trichloroethene	830	T	--	--	--	170	--	--
1,1-Dichloroethene	--	--	--	--	--	33	40	--
Trans-1,2-dichloroethene	T	--	T	--	--	35	48	--
Toluene	--	24	--	--	--	--	--	--

[1]Although a complete volatile organic scan was performed on all samples listed, only positive results are presented in this table. Compounds normally reported in a volatile organic scan but not listed in this table were not detected.

[2]Seven samples were taken between 70 feet and 150 feet. No volatiles were detected.

[3]Seven samples were taken between 5 feet and 92 feet. No volatiles were detected.

KEY:

-- = Compound not detected.
T = Trace compound detected at concentration below the stated 10 ppb detection limit.

Sample dates: 22M, October 31-November 16, 1984; W4M, November 19, 1984; 23M, November 26-30, 1984

TABLE 4

SUMMARY OF VOLATILE ORGANIC ANALYSIS OF GROUNDWATER SAMPLES FROM THE SUPPLEMENTAL WELLS[1]
(Concentrations in ppb)

Compound	Well No. W1S Sampling Date		Well No. W2S Sampling Date		Well No. 3S Sampling Date		Well No. 4S Sampling Date		Well No. 5S Sampling Date		Well No. 6S Sampling Date	
	a	b	a	b	a	b	a	b	a[2]	b	a	b
1,1,1-Trichloroethane	290	--	--	--	12	13	--	--	43	19	--	--
1,1-Dichloroethane	--	--	--	--	28	19	--	--	110	170	--	--
1,2-Dichloroethane	--	--	--	--	--	--	--	--	--	--	--	--
Chloroethane	--	--	--	--	--	--	--	--	--	--	--	--
Trichloroethene	51	86	--	--	--	--	430	470	69	49	--	--
1,1-Dichloroethene	49	--	--	--	--	--	--	--	22	13	--	--
Trans-1,2-dichloroethene	22	16	--	--	--	T	84	71	21	26	--	--
Chloroethene	--	--	--	--	--	--	--	--	--	--	--	--

[1]Although a complete volatile organic scan was performed on all samples listed, only positive results are presented in this table. Compounds normally reported in a volatile organic scan but not listed in this table were not detected.

[2]Benzene also detected at 13 ppb.

[3]Benzene also detected at 22 ppb.

[4]Toluene at 24 ppb and xylenes at 770 ppb detected.

Key:

-- = Compound not detected
T = Trace compound detected at concentration below the stated 10 ppb detection limit
NS = Well not sampled on date indicated

Sampling dates: a = February 6-7, 1985, b = February 20-21, 1985

TABLE 4 (continued)

Compound	Well No. 4M Sampling Date		Well No. 22M Sampling Date		Well No. 23M Sampling Date		Well No. 24S Sampling Date	
	a[5]	b[6]	a[7]	b	a[8]	b[9]	a	b
1,1,1-Trichloroethane	1,000	900	--	--	--	--	--	--
1,1-Dichloroethane	260	110	--	--	--	--	--	--
1,2-Dichloroethane	--	--	--	--	--	--	--	--
Chloroethane	--	--	--	--	--	--	--	--
Trichloroethene	240	190	560	560	--	--	--	--
1,1-Dichloroethene	76	30	--	--	--	--	--	--
Trans-1,2-dichloroethene	92	98	88	62	T	--	--	--
Chloroethene	--	--	--	--	--	--	--	--

[1]Although a complete volatile organic scan was performed on all samples listed, only positive results are presented in this table. Compounds normally reported in a volatile organic scan but not listed in this table were not detected.

[2]Benzene also detected at 13 ppb.

[3]Benzene also detected at 22 ppb.

[4]Toluene at 24 ppb and xylenes at 770 ppb detected.

[5]Chloroform at 22 ppb and tetrachloroethene at 160 ppb also detected.

[6]Tetrachloroethene also detected at 230 ppb.

[7]Benzene also detected at 22 ppb.

[8]Toluene at 24 ppb and xylenes at 770 ppb detected.

[9]Toluene at 120 ppb and xylenes at 870 ppb detected.

Key:

-- = Compound not detected
T = Trace compound detected at concentration below the stated 10 ppb detection limit
NS = Well not sampled on date indicated

Sampling dates: a = February 6-7, 1985, b = February 20-21, 1985

ranging up to 560 ppb. Although concentrations of other volatiles (e.g., toluene and xylene) were also detected on occasion, as indicated in the table, such detection was sporadic and isolated and is therefore considered anomalous.

Site survey.

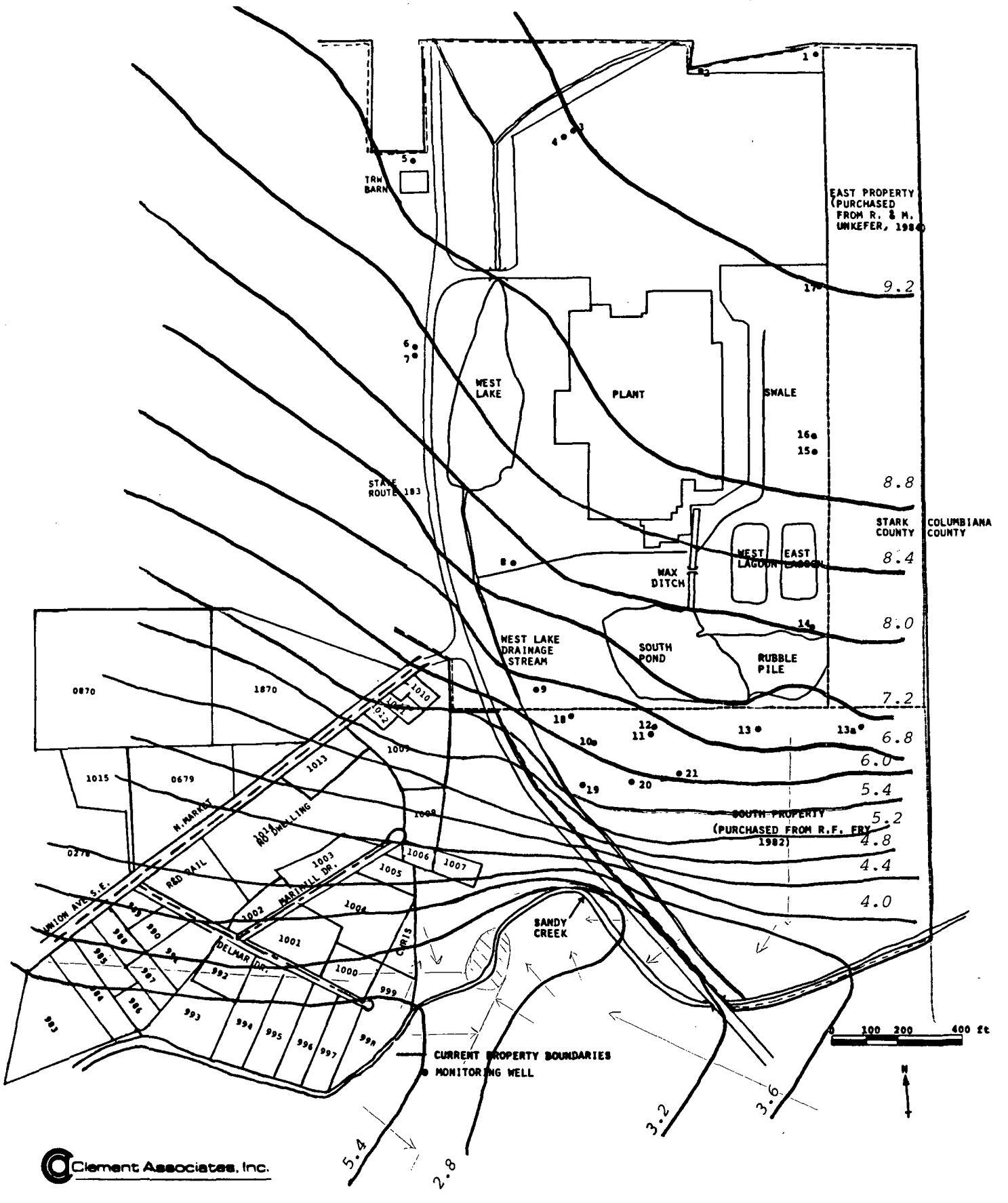
A topographic survey of the site was completed and is presented in Appendix 2. The survey includes ground contours to 2 feet, locations of all topographic features on the site, and locations and elevations of monitoring wells.

Pump test. Results of the pump test are presented in Appendix 8. The data were used to determine the hydraulic conductivity of the aquifer. This value was calculated to be on the order of 10^{-2} cm/sec. This is considered a reasonable value for the sand and gravel encountered in the monitoring well borings.

Groundwater modeling. The steady state groundwater flow condition, as predicted by the flow modeling is shown in Figure 10. The contours indicate that south of the plant the groundwater flow is due south. North of the plant the groundwater flow is south-southwest. The increasing proximity of the contour lines south of the plant may be due to the presence of lower permeability clay in this area. The model assumes that Sandy Creek is a gaining stream that is being recharged by groundwater. South Pond and West Lake contribute to groundwater flow but do not affect the groundwater flow direction significantly. The West Lake stream does not appear to impact the overall

FIGURE 10

STEADY STATE GROUNDWATER FLOW CONTOURS
AT THE TRW SITE, MINERVA, OHIO



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flow pattern. Results of well withdrawal simulations (also generated as part of the modeling effort) are discussed in Chapter III of this report. Additional information on the model, its calibration, and results are presented in Appendix 9.

b. Data Analysis Conclusions

The distribution of contaminants south of the site is presented in a series of figures. Figures 11-16 depict, respectively, measured contaminant plumes for total volatile organics, total saturated organics, total unsaturated organics and each of the three main constituents: TCE, trans-1,2-DCE and 1,1-DCA. Figure 17 shows other contaminants exhibiting no obvious pattern. A second area of contamination is located near the TRW barn. Figures 18 and 19 depict, respectively, the known distribution of saturated and unsaturated contaminants in this second area.

Based on an analysis of the contaminant patterns depicted along with groundwater flow modeling results and the other data developed the following conclusions are made:

1. Groundwater south of the site flows toward the south. Groundwater movement is slowed in this area because of the presence of clay intermixed in the local sands and soils. Groundwater in the barn area flows southwest.

2. South of the TRW plant there appear to be two contaminant plumes. The first is southwest of South Pond and contains primarily TCE and trans-1,2-DCE. Since the highest concentrations are located at well 19 and decrease in all directions from that well (including upgradient), it appears that the source

FIGURE 11

CONCENTRATION OF TOTAL VOLATILE ORGANICS IN GROUNDWATER AT THE TRW SITE, MINERVA, OHIO*

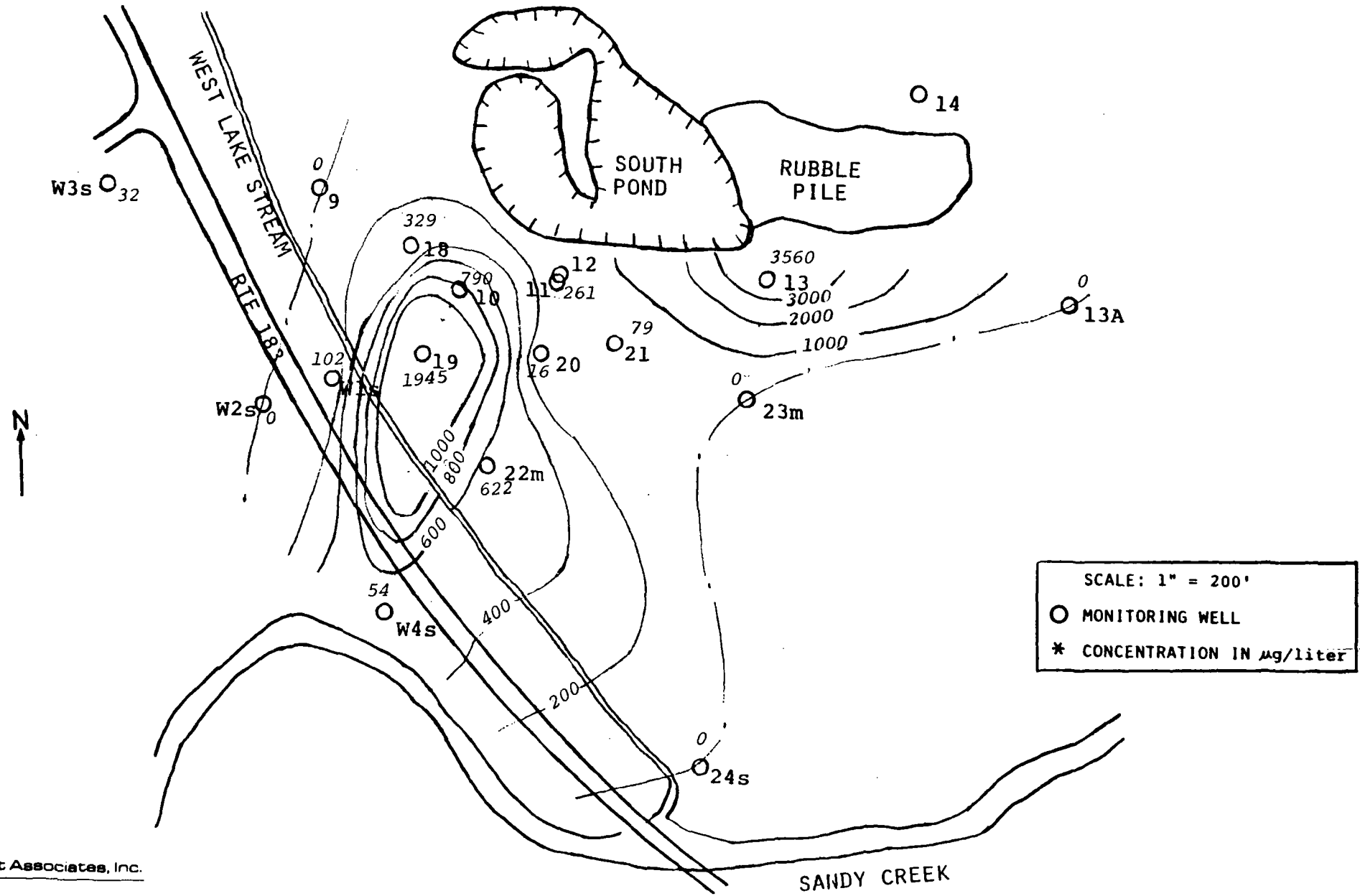

FIGURE 12

CONCENTRATION OF TOTAL SATURATED VOLATILE ORGANICS IN GROUNDWATER AT THE TRW SITE, MINERVA, OHIO

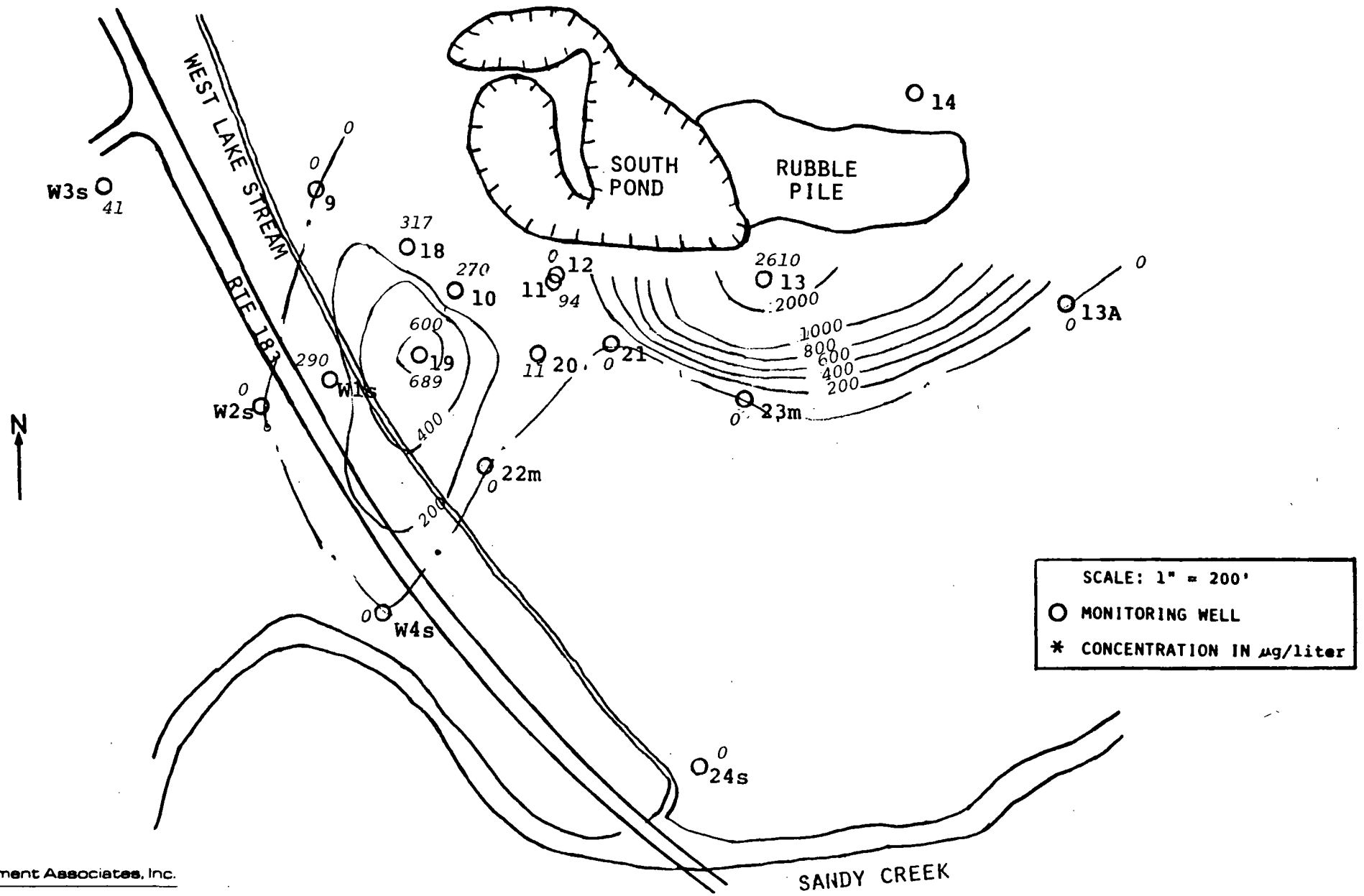

FIGURE 13

CONCENTRATION OF TOTAL UNSATURATED VOLATILE ORGANICS
IN GROUNDWATER AT THE TRW SITE, MINERVA, OHIO

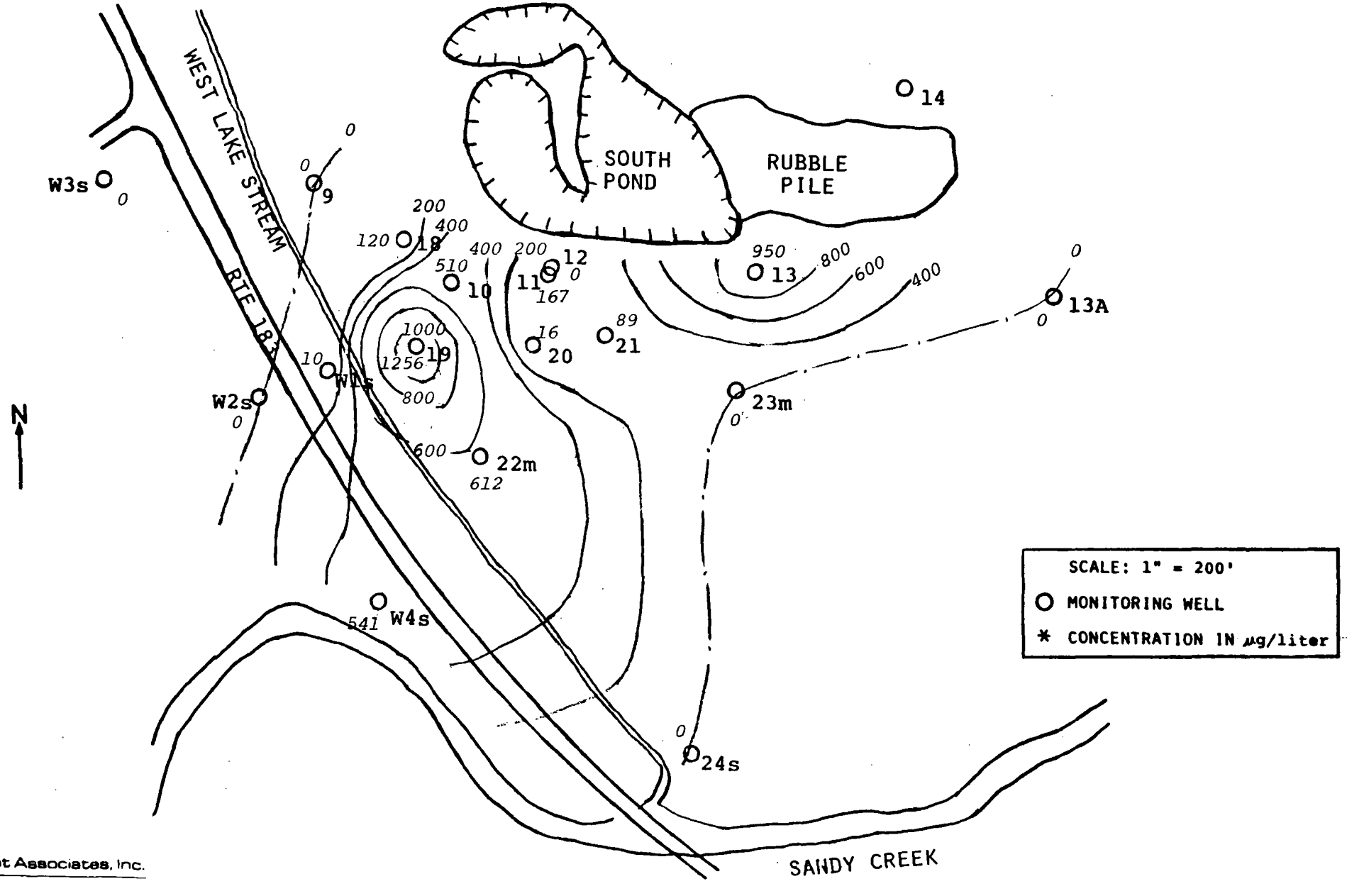

FIGURE 14

CONCENTRATION OF TRANS-1,2-DICHLOROETHENE IN GROUNDWATER AT THE TRW SITE, MINERVA, OHIO*

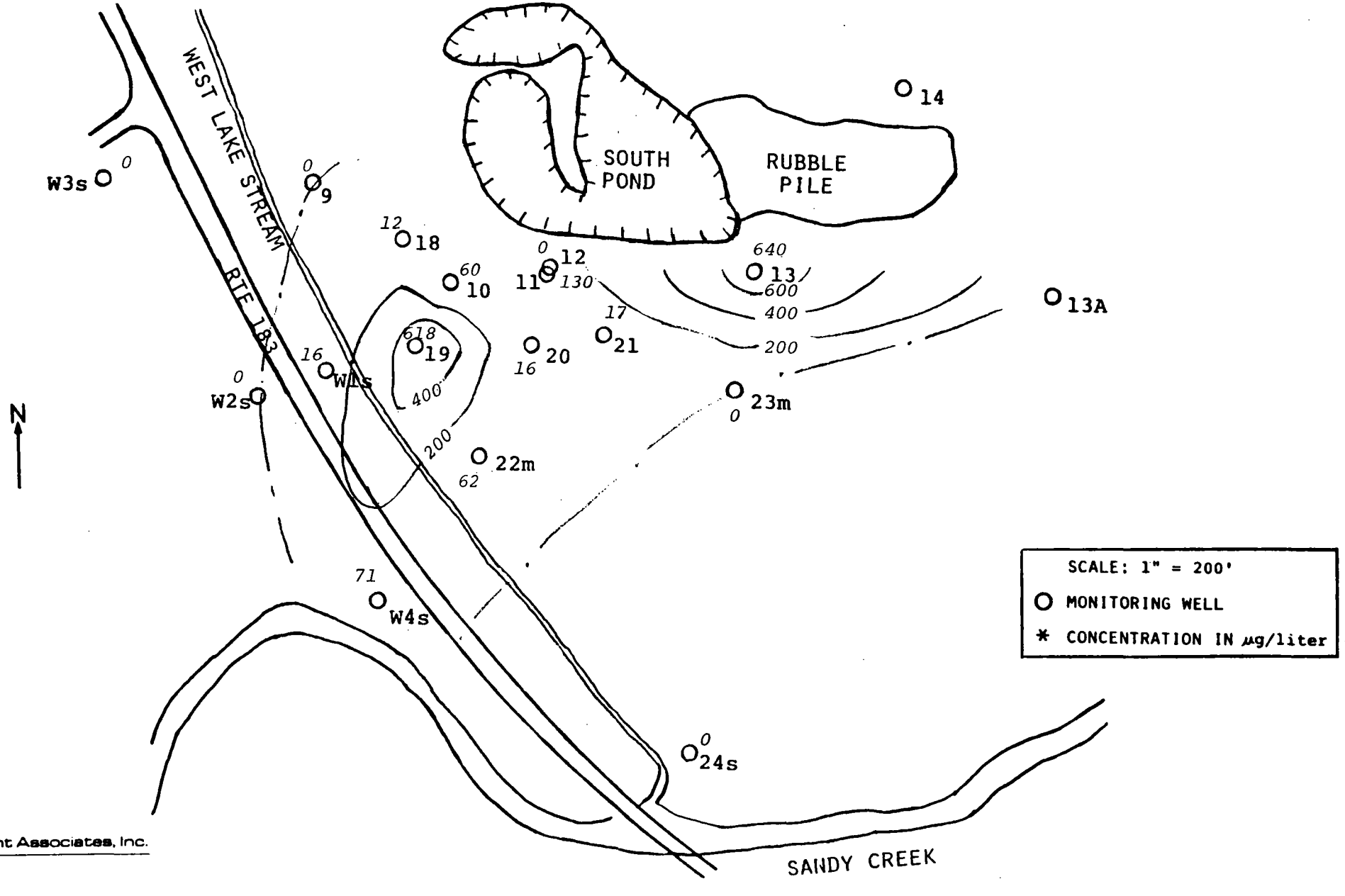

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FIGURE 15

CONCENTRATION OF 1,1-DICHLOROETHANE IN GROUNDWATER AT THE TRW SITE, MINERVA, OHIO*

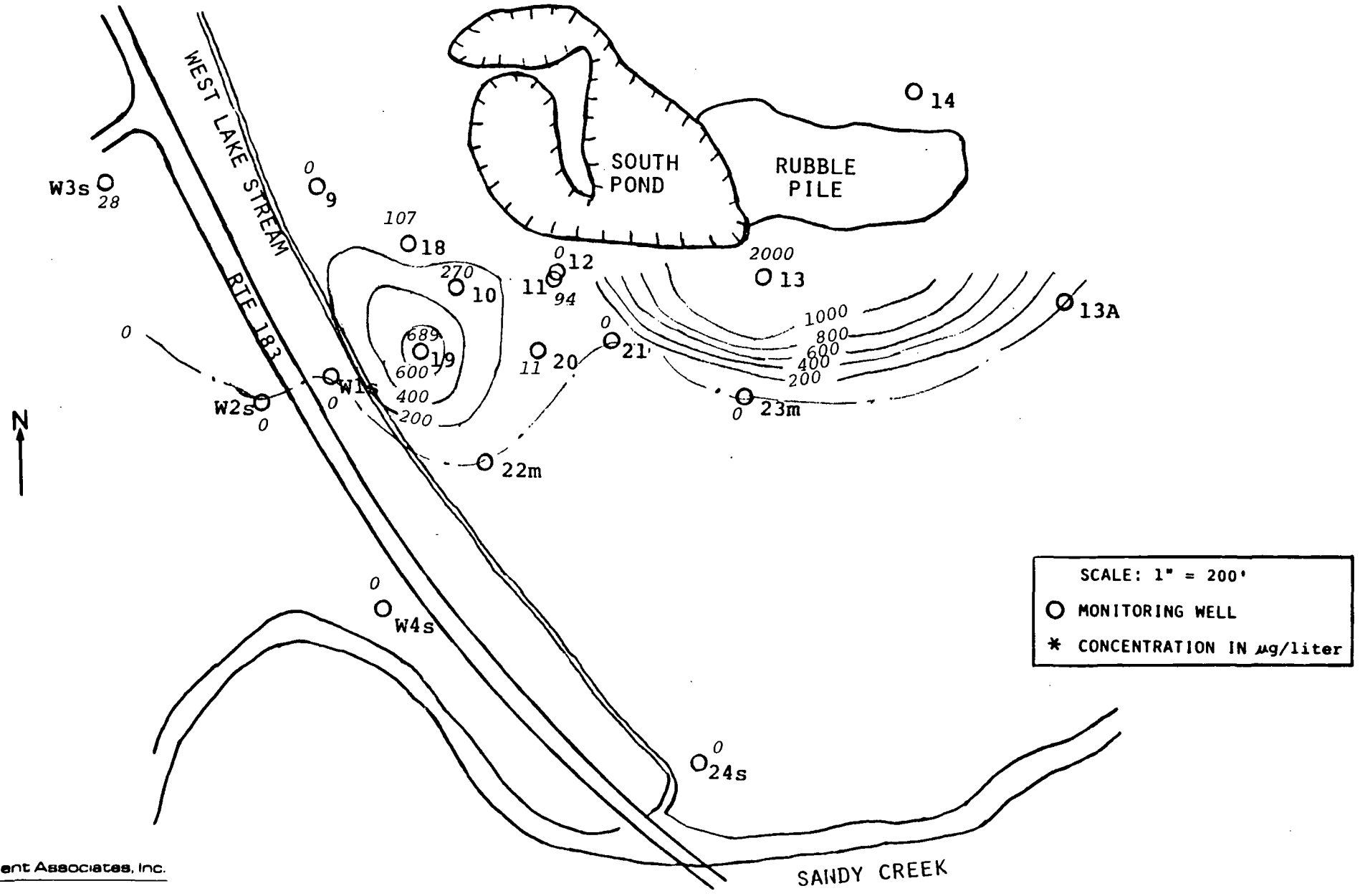

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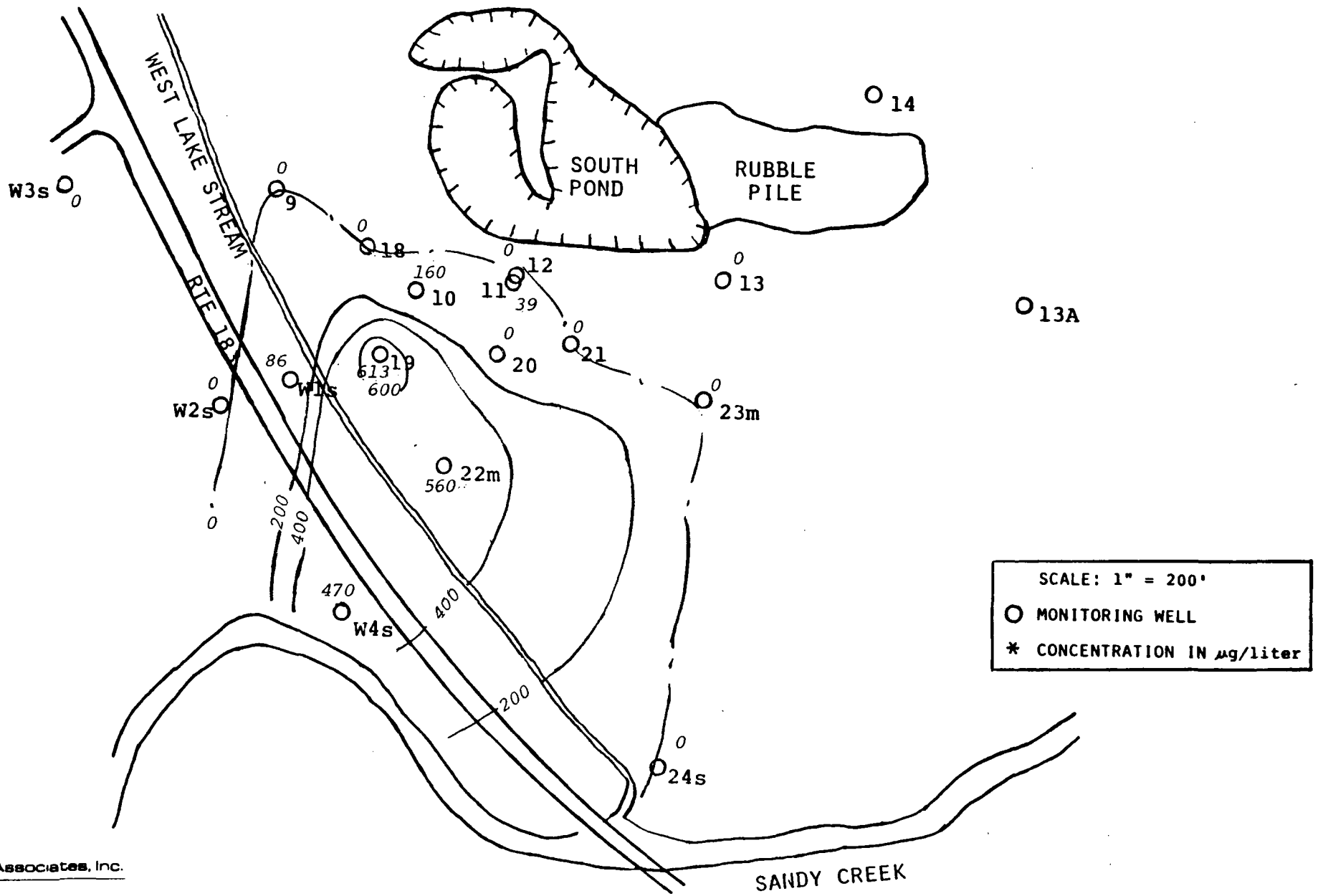
FIGURE 16

CONCENTRATION OF TRICHLOROETHENE IN GROUNDWATER AT THE TRW SITE, MINERVA, OHIO*



APPENDIX 1

Groundwater Treatment Feasibility Study Work Plan

AMENDED
PROPOSED GROUNDWATER TREATMENT FEASIBILITY STUDY FOR THE TRW SITE IN MINERVA, OHIO

(Supercedes the Proposed Study Submitted on September 14, 1984)

Prepared for:

TRW Inc.
Minerva, Ohio

Prepared by:

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1515 Wilson Boulevard
Arlington, VA 22209

December 7, 1984

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Introduction

This work plan outlines procedures for assessing the full extent of volatile organic contamination in the groundwater and other aquifer characteristics necessary to design a proposed groundwater treatment system at the TRW site in Minerva, Ohio. The vertical and horizontal profiles of volatile organic concentrations in groundwater will be determined as part of this study. In addition, samples from representative wells on site, where volatile organics have been detected, will be subjected to a complete priority pollutant scan to ensure that the scope of materials introduced into groundwater at the TRW site has been completely identified. Although the possibility is remote that volatile organics have spread significantly in a direction lateral to groundwater flow, private wells in a nearby residential community will be sampled to confirm that volatile organics have not migrated off site and are not impacting local residents. Sandy Creek will also be sampled as a preliminary indication of the extent of volatile organic migration.

The hydraulic conductivity and transmissivity of the local aquifer will be determined in a pump test. A site survey will also be conducted to determine stream bed elevations and new monitoring well locations, which will be required as input parameters for computer modeling. Once aquifer characteristics are determined, a computer model of the aquifer will be developed to test trial configurations for designing a groundwater withdrawal field.

Work tasks proposed as part of this feasibility study will be carried out in phases so that results of earlier analyses can be used to modify plans for later tasks to maximize efficiency. Work tasks discussed in later phases include decision criteria for considering modifications. The following technical approach includes eight tasks arranged in three phases as follows:

A. Initial Sampling

Task 1. Residential Well Sampling
Task 2. Sandy Creek Sampling
Task 3. Priority Pollutant Investigation

B. Volatile Organic Profile Determination

Task 4. Initial Monitoring Well Investigation
Task 5. Supplemental Monitoring Well Investigation

C. Aquifer Characterization

Task 6. Site Survey
Task 7. Pump Test
Task 8. Groundwater Flow Modeling

Technical Approach

The eight tasks of this feasibility study are detailed in the following paragraphs. Quality assurance/quality control protocols for sample handling and analysis are provided in Appendix A. A preliminary schedule is presented in Appendix B.

A. Initial Sampling

Task 1: Residential Well Sampling

Private wells of residents living closest to the TRW facility will be sampled to determine whether volatile organics detected in groundwater at the Minerva site have migrated off site. Houses in an area immediately southwest of the TRW facility

(Figure 1) will be surveyed to determine the number and location of private wells in this target area. Residents in the target area will have the opportunity to have their wells sampled. Samples will be collected from the earliest access point on the line as close to the pump as feasible.

Samples will be collected in such a manner as to minimize air entrainment. Specific residential well sampling procedures will be developed by the sampling laboratory and are subject to approval by Clement Associates. Sample labeling, handling, and storage will be carried out as prescribed in Appendix A. All samples collected will be analyzed for volatile organics, pH, specific conductance, total organic halogen (TOX), and PCBs by the EPA-approved protocols for each parameter (as cited in Appendix A).

Task 2: Sandy Creek Sampling

To test for the possibility that volatile organics have reached Sandy Creek, several surface water samples will be collected in the creek. Surface water samples will be collected from a point upstream of the TRW facility, a central point on the facility, and a point downstream of the facility in the approximate locations depicted in Figure 2. In addition, the portion of the creek located on the TRW property will be inspected for signs of seeps on the north side of the creek. If any seeps into the creek are observed, they will also be sampled. In order to prevent upstream sediment from affecting

FIGURE 1

AREA WHERE PRIVATE WELLS WILL BE SAMPLED AS PART OF AN INVESTIGATION AT THE TRW SITE IN MINERVA, OHIO

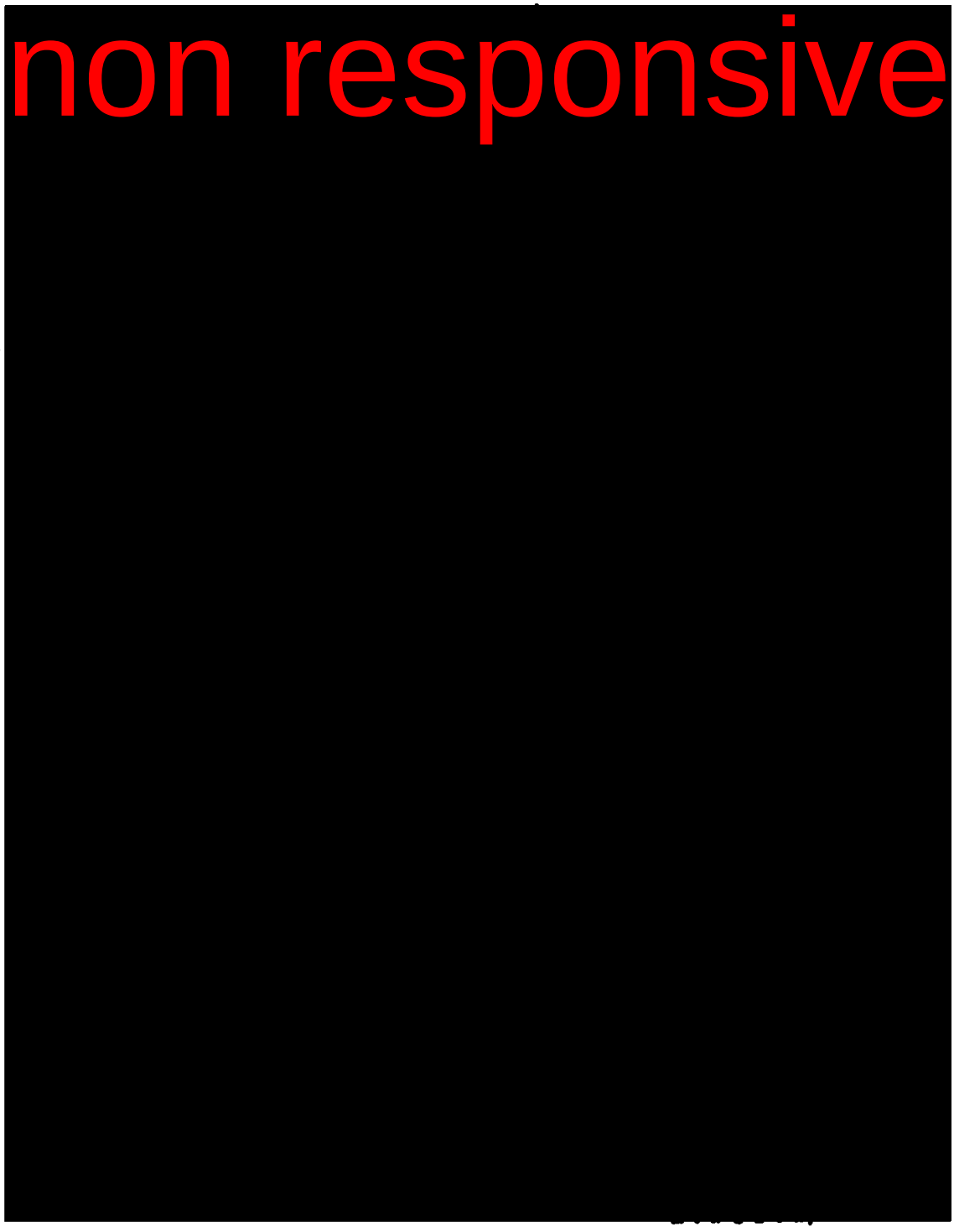
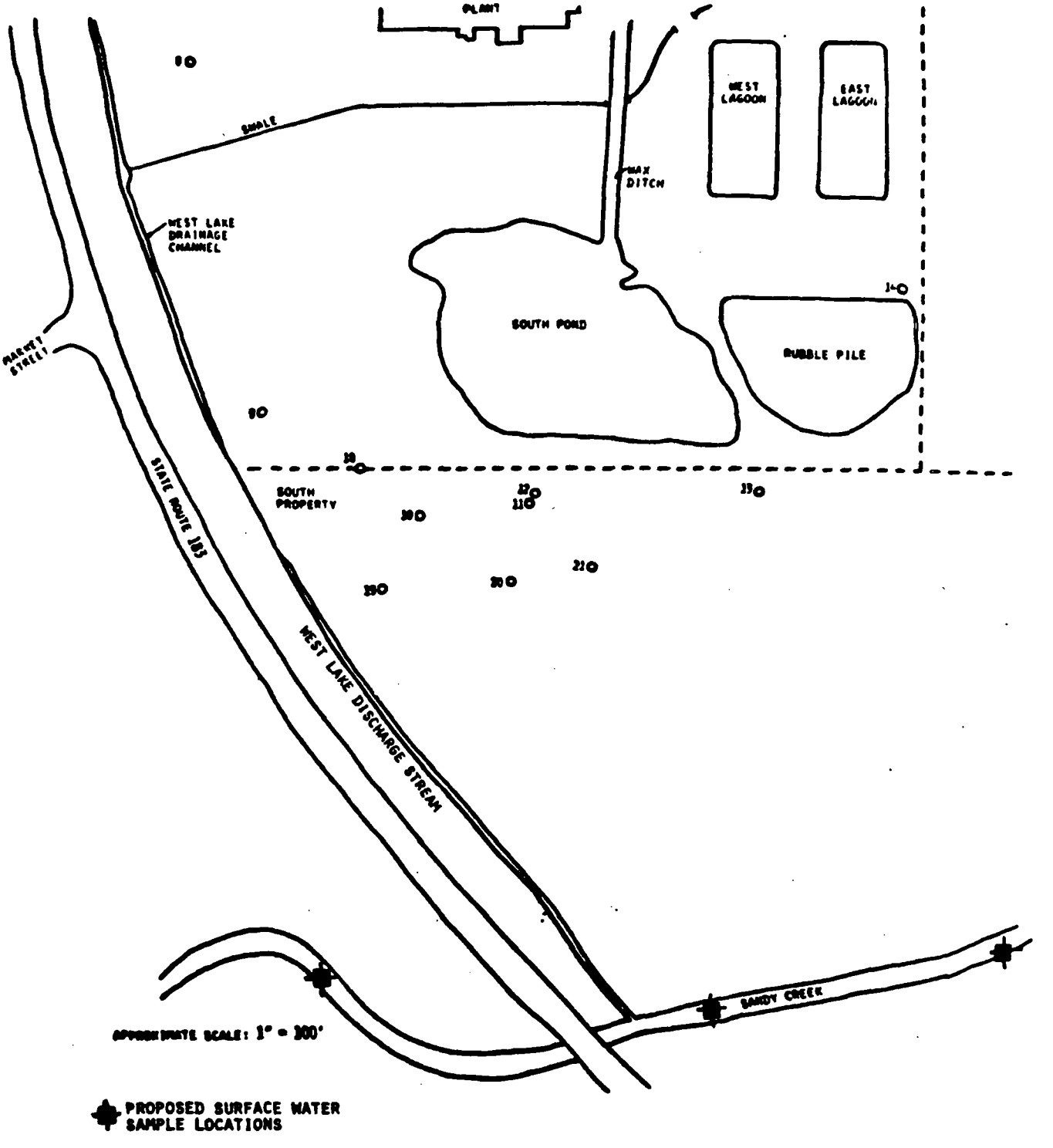


FIGURE 2

PROPOSED LOCATIONS FOR SANDY CREEK SAMPLES AT THE TRW SITE IN MINERVA, OHIO (SEPTEMBER 1984)



the measurements, sampling will be conducted at least 3 days after any rainfall has occurred.

Samples will be collected using a dipper and will be rapidly transferred with minimal agitation to glass bottles, which will be tightly sealed. All surface water samples collected from Sandy Creek will be analyzed for volatile organics using the EPA-approved protocols. Sample labeling, handling, storage, and analysis will be conducted as prescribed in Appendix A.

Task 3: Priority Pollutant Investigation

Representative wells at the TRW site will be subjected to a priority pollutant scan to confirm that all major groundwater contaminants have been detected at the TRW site. The existing wells 1[a], 10, 13, and 19 have been selected for this investigation because these wells currently exhibit the highest levels of volatile organics detected at the Minerva site. Locations of existing monitoring wells are shown in Figure 3. Groundwater sampling and sample labeling, handling, storage, and analysis will be conducted as prescribed in Appendix A.

B. Volatile Organic Profile Determination

Additional monitoring wells will be installed downgradient of existing wells at the TRW site to determine the vertical and areal extent of volatile organic concentrations in groundwater. Wells will be installed in two intervals so results obtained from the first set of new wells can be used to guide

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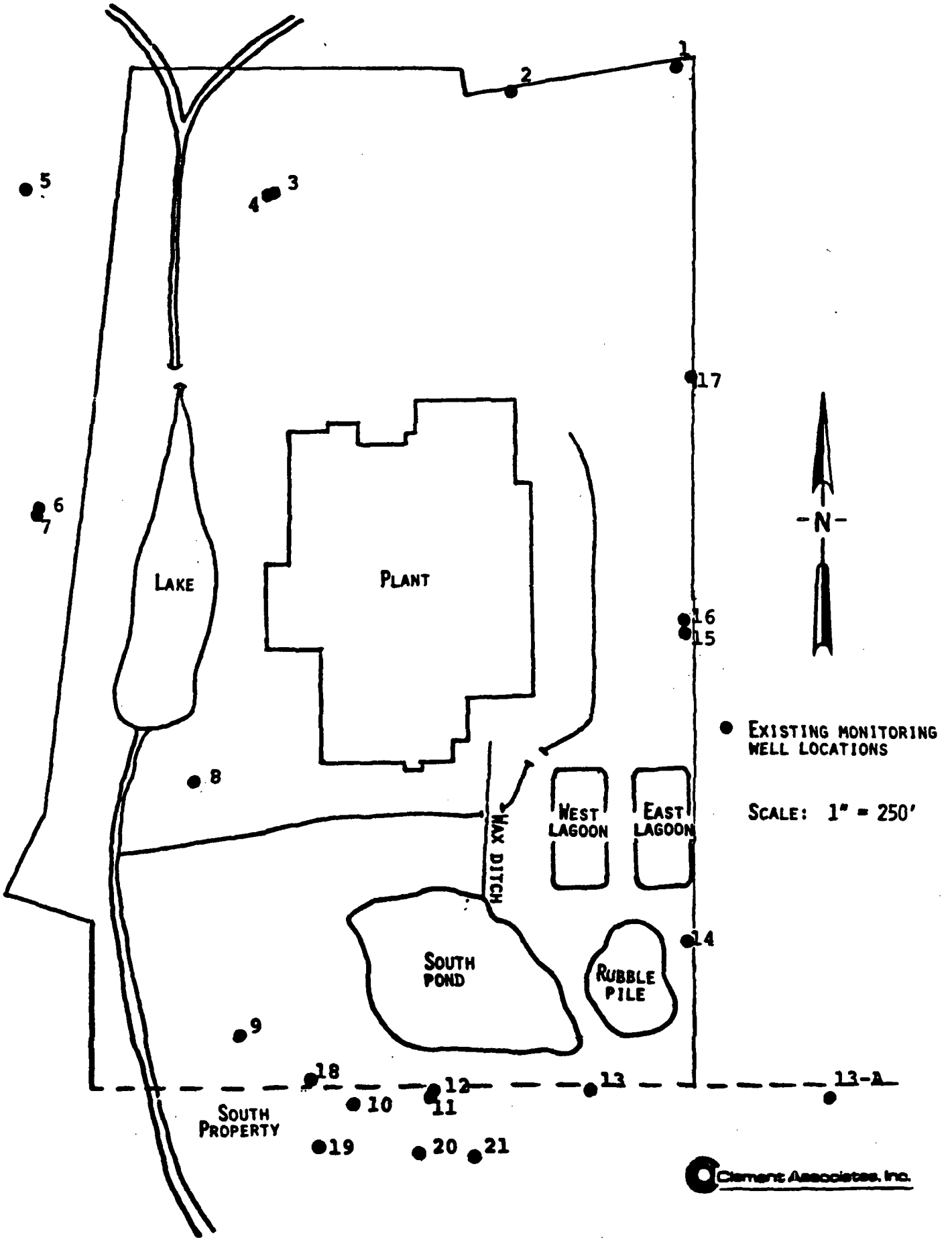
[a]Well 1 serves as an upgradient control.

FIGURE 3
EXISTING MONITORING WELL LOCATIONS AT THE TRW MINERVA SITE



the placement of the second set of wells. The numbering of new wells will be consistent with the numbering of existing wells.

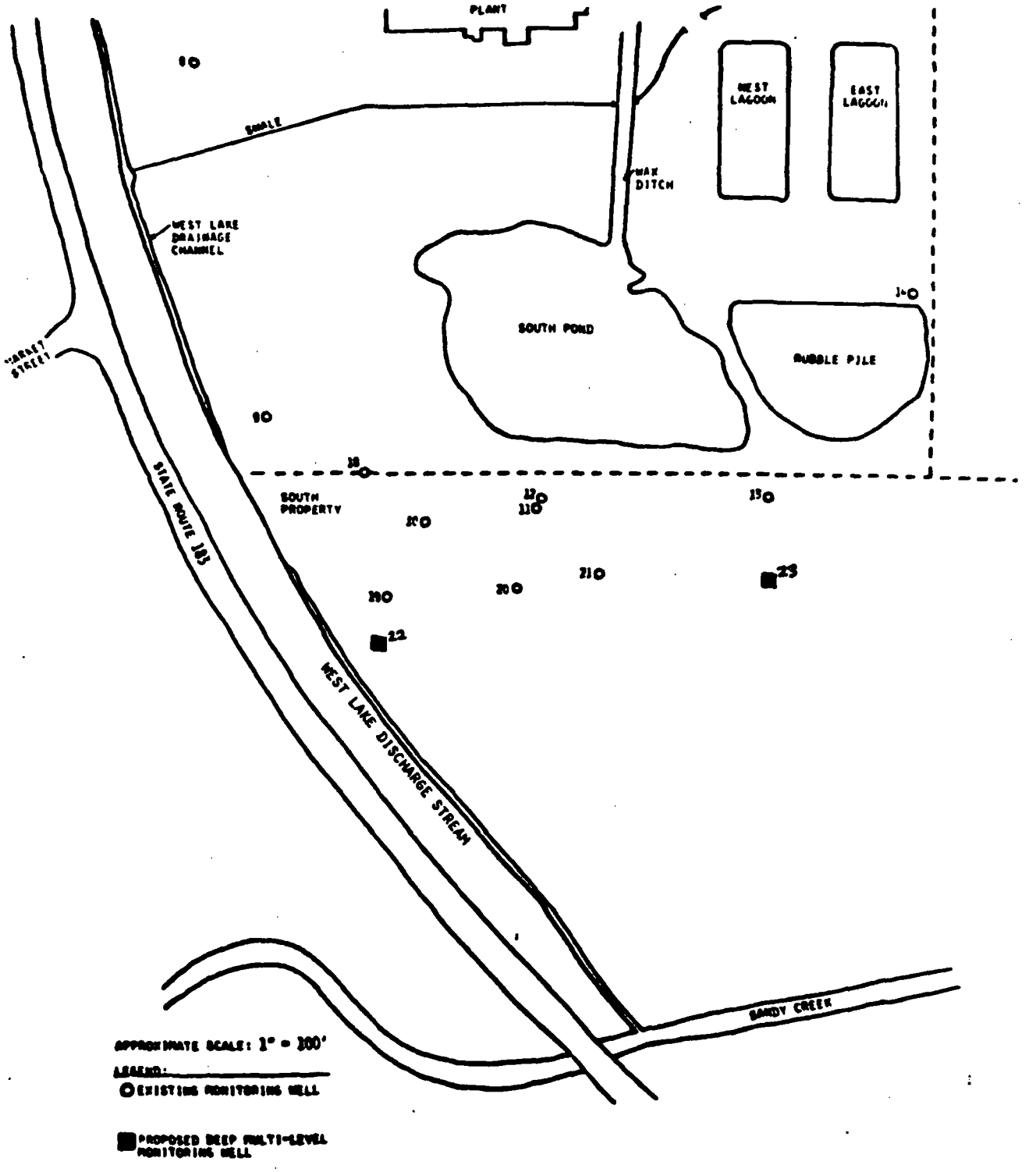
Two types of wells will be installed as part of this project, single wells and multi wells. Multi wells will be advanced in a manner allowing collection of groundwater samples from defined depth intervals during drilling and will be developed over a single interval based on results of the multi-level analysis. Single wells will be advanced and developed at a single defined depth interval. Well specifications and procedures for well drilling and development are provided in Appendix C.

Task 4: Initial Monitoring Well Installation

The first set of new monitoring wells will be used to determine the relationship between the distance downgradient from the TRW facility and volatile organic concentrations in groundwater near the surface of the aquifer in addition to providing an indication of the vertical profile of volatile organics. Three multi wells will be installed for this purpose. One well will be located along the approximate center line of each of the two contaminant plumes detected under the South Property at the site. Proposed locations for these two new wells are shown in Figure 4. The new monitoring well 22m will be located as near to 150 feet downgradient of well 19 as feasible, subject to the constraint that the well must remain at least 30 feet from the stream that drains West Lake (see Figure 4). As a consequence, the location of well 22m will likely be rotated

FIGURE 4

PROPOSED MULTI-LEVEL MONITORING WELLS ON THE SOUTH PROPERTY AT THE TRW SITE IN MINERVA, OHIO



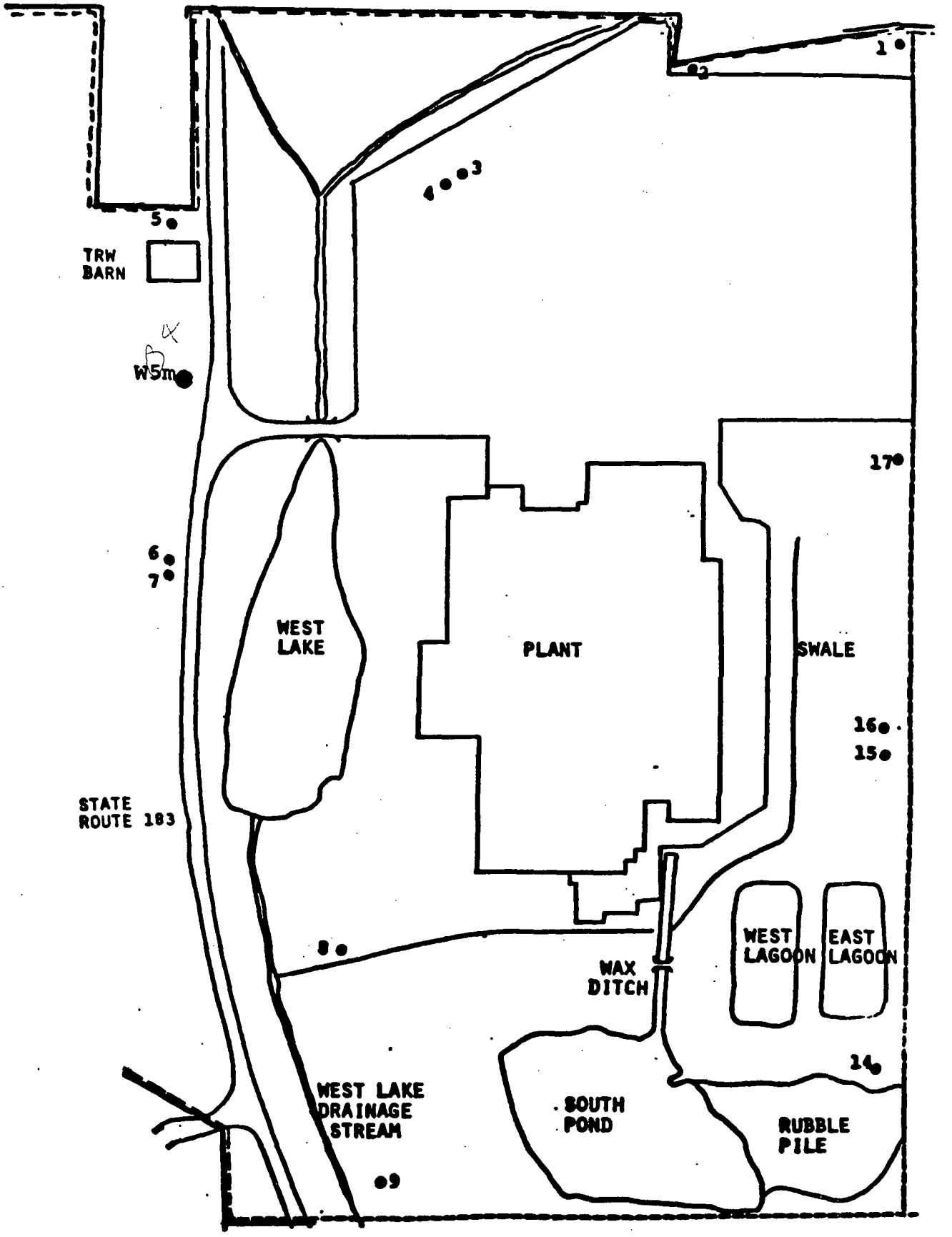
slightly further south than the center line of the plume passing through wells 10 and 19 would dictate. Thus, well 22m will be far enough from the stream to prevent interference from surface water effects while remaining generally downgradient of well 19. The new well 23m will be placed 150 feet downgradient of the existing well 13, intersecting the plume currently intercepted by well 13.

To determine the vertical profile of volatile organic concentrations in groundwater, both wells will be sunk to bedrock (approximately 90 feet below the water table). During advancement, groundwater will be sampled at approximately 13-foot intervals in these wells (per the procedure defined in Appendix C) from the groundwater surface to the bedrock. The final screen length will be determined by analysis of the interval samples.

A third multi well (W4m) will be installed as part of this task to determine the source of the volatile organics detected in a production well by the TRW barn. The well will be located downgradient of the barn approximately halfway between the barn production well and the existing monitoring wells 6 and 7 as indicated in Figure 5. Multi well W4m will be advanced to bedrock as prescribed in Appendix C.

Groundwater level measurements as well as the level in West Lake, South Pond, and Sandy Creek will also be recorded in all of the monitoring wells at the TRW site at the same time that sampling is performed in the new wells. In addition,

FIGURE 6
PROPOSED MONITORING WELL IN THE BARN AREA
AT THE TRW SITE IN MINERVA, OHIO



wells 1, 10, 13, and 19 will be sampled for volatile organic analysis during this period. Sample collection, labeling, handling, storage, and analysis will be conducted as prescribed in Appendix A.

Task 5: Supplemental Monitoring Well Investigation

Subject to results obtained in Task 4, additional groundwater monitoring wells (single wells) will be installed at the TRW site to determine the location of the leading edge of volatile organic concentrations in groundwater and to better determine groundwater contours in the area. At least one well will be placed just upgradient of Sandy Creek. Up to three wells will be installed on the South Property. In addition, up to three wells will be placed to the west of highway 183 and the drainage stream emanating from West Lake to determine the effect that this stream has on local groundwater flow. A single well will also be installed upgradient of the barn. The location and depth of this well will be determined by the results of multi well sampling south of the barn.

Exact locations for new wells will be determined by evaluation of the results obtained in Task 4 and, thus, cannot be presented at this time. At least one of the wells will be constructed with a sufficient diameter (at least 4 inches) and placed within 100 feet of well 22m or 23m in anticipation of a pump test. The remaining wells will be constructed of 2-inch-diameter carbon-steel casings and stainless-steel screens (as prescribed in Appendix C). Well installation and development

will be performed as prescribed in Appendix C. Wells will be screened at the depth in the aquifer where the greatest concentrations of volatile organics are expected, based on results from Task 4.

Once wells are developed, groundwater samples will be collected from each of the new wells and analyzed for volatile organics, pH, specific conductance, and TOX. Groundwater levels in all of the wells at the TRW site will also be recorded at the time of sampling. Water levels in West Lake, South Pond, and Sandy Creek will also be determined at this time. Sample collection, labeling, handling, and analysis will be performed as described in Appendix A.

C. Aquifer Characterization

The hydraulic properties of the aquifer will be determined in this phase so that the aquifer may be modeled and a well withdrawal field can be designed. To provide input parameters for the anticipated modeling, a site survey will be conducted and a pumping test will be run.

Task 6: Site Survey

A topographic map will be prepared by aerial survey and ground-control methods to encompass the site study area. This survey represents a supplement to the survey conducted by O'Brien and Gere in 1983, and only additional sections of the study area not yet surveyed will be included in the new investigation. The area of interest runs from the southern boundary of South Pond on the north to 100 feet south of Sandy Creek, and from

route 183 on the west to the TRW property line on the east. The location and elevation of stand pipes for the new monitoring wells will also be determined as part of this survey. Finally, stream inverts will be developed for the portion of Sandy Creek on the TRW property and the drainage stream emanating from West Lake. Specific benchmarks will be established at points where large rocks or dense soil provide a stable base in both streambeds. Benchmarks will be established every 100 feet. These points will be used later to determine water levels in each stream. The information collected during the survey will be presented on a map with a scale of 1 inch:50 feet and 2-foot contour intervals. Well stand pipe elevations and stream benchmarks will be reported to the nearest 0.1 inch.

Task 7: Pump Test

A nonsteady-state pumping test will be conducted on site to determine hydraulic characteristics of the aquifer. Two of the new monitoring wells located within 100 feet of each other will be employed for this purpose. The test will be developed based on results of Tasks 4 and 5. Based on the reported discharge rates of existing monitoring wells and other local wells, a pumping rate between 50 and 70 gallons per minute should be sufficient for this test. Therefore, over an 8-hour period, approximately 34,000 gallons of wastewater will be generated. It is anticipated that this volume is sufficiently small that it can be discharged to South Pond.

Task 8: Groundwater Flow Modeling

A computer model of groundwater flow and contaminant transport in the aquifer under the TRW site will be run to determine potential risks associated with migration of volatile organics present in groundwater at the site and to evaluate the effectiveness of various groundwater treatment schemes. Part of the analysis will include a determination on the optimum groundwater withdrawal system that will preclude further contaminant migration at the TRW facility while minimizing the impact on surrounding users of local groundwater. Models chosen for this evaluation will be determined by results of the groundwater monitoring program outlined above, and details will be provided at that time. Computer programs used for modeling will be selected from the set of such programs reviewed and approved by EPA.

APPENDIX A

PROTOCOLS AND PROCEDURES FOR THE FEASIBILITY STUDY AT THE TRW SITE IN MINERVA, OHIO

The following protocols are recommended for sample collection, handling, storage, and transport. Methods are designed to insure sample integrity. Protocols will be finalized once discussions with the selected analytical lab are completed.

A. Sample Locations

The on-site benchmarks established as part of the O'Brien and Gere survey will be used as a ground control to establish the monitoring well grid.

B. Sample Collection

The following procedures will be followed for sample collection.

1. Surface water samples

Surface water samples will be collected from Sandy Creek as near the bottom of the creek as feasible while avoiding collecting significant sediment. Samples will be collected in such a manner as to minimize air entrainment. A specific method will be developed by the laboratory subject to approval by Clement Associates. Samples will then be transferred to clean glass jars with airtight caps and preserved as specified in analysis protocols for each of the analyses to be performed.

2. Groundwater samples

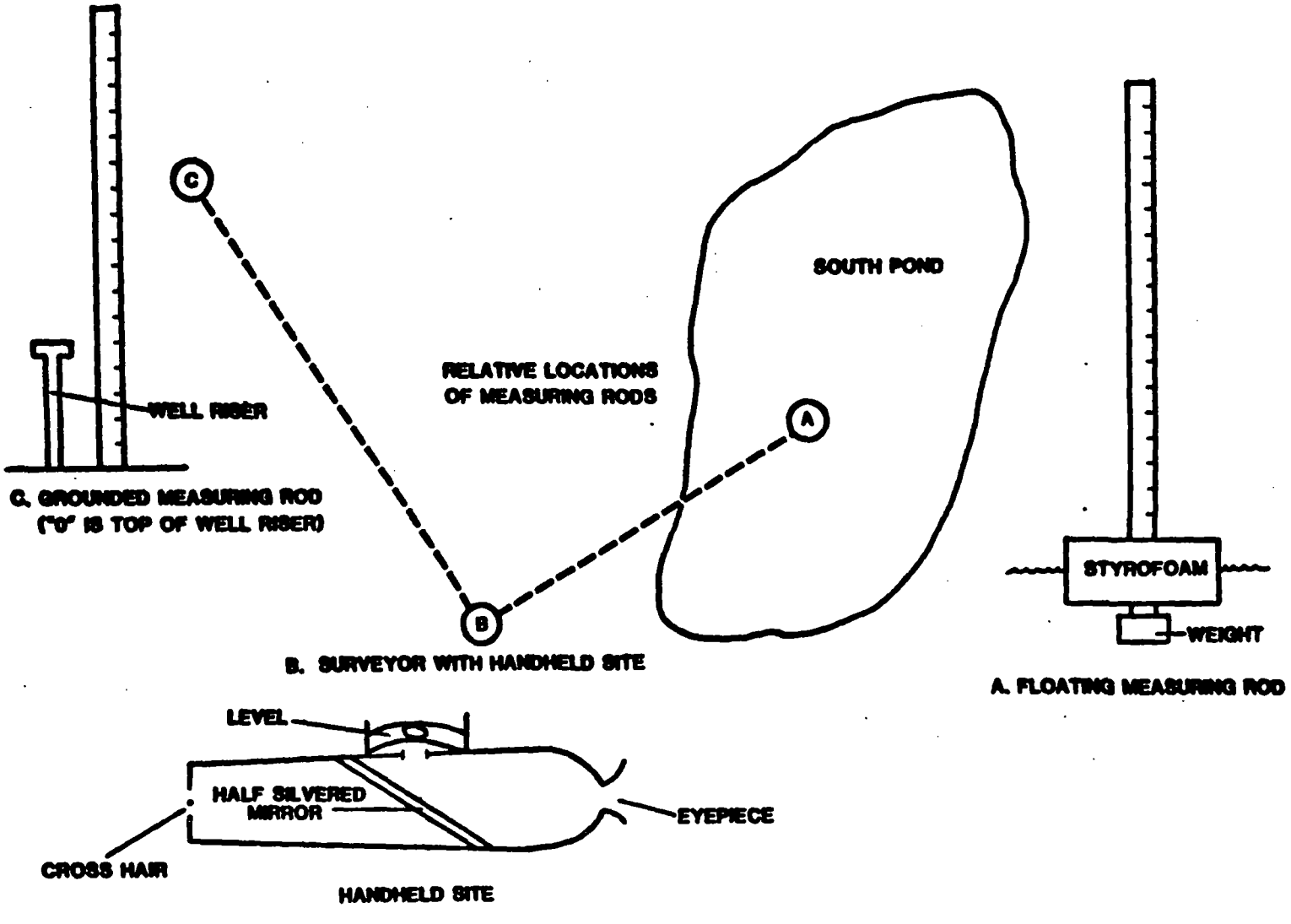
Groundwater samples will be collected by bailer. Formation samples will be collected with a clean sample taker. A longitudinal cross-section from the sample taker will then be transferred as a representative sample of the depth interval collected. All samples will be transferred to clean glass jars and preserved as prescribed in analysis protocols for each of the analyses to be performed.

3. Water level determination

The water level in each well will be measured with a hand-held electric water level finder. The water level finder consists of an electrode attached to a 250-foot cable, a cable reel, a battery, and an ampmeter. The electrode is lowered into the well and the ampmeter registers a reading when the electrode contacts the water surface. The depth is then read off the cable. Water levels in streams and creeks will be determined by measuring the depth of water above established benchmarks with a dipstick. The water level in South Pond or West Lake will be measured using a hand held level site. A float supporting a vertical stick ruled to 1 inch is placed in South Pond (or West Lake), see Figure A-1 (the "zero" on the stick should be set at the level of the water surface.) A similar stick is secured to a neighboring monitoring well riser with zero corresponding to the top of the riser. The water level in either surface water body is then determined by siting

FIGURE A-1

STRATEGY AND EQUIPMENT FOR MEASURING THE WATER LEVEL IN SOUTH POND OR WEST LAKE



both sticks with the hand held site and recording the respective vertical distances from the horizontal defined by the optical piece to the surface of the pond and to the top of the well riser. This level is recorded to within 1 inch.

C. Cleaning

All sampling and drilling equipment will be decontaminated before use and after collection of each sample to prevent cross-contamination. Equipment will first be wiped clean with a clean cloth of all materials that may adsorb organics. Large equipment such as drilling equipment may be steam cleaned as an alternative to wiping. Following a thorough wiping, the equipment will be rinsed liberally with distilled water. Excess water will be shaken off and the equipment will then be rinsed with methanol. Methanol will be allowed to evaporate prior to equipment use. Cloth used for wiping will be placed in an appropriately labeled 55-gallon drum for storage and eventual disposal. Spent rinses will be discharged to South Pond.

D. Sample Labels

Sample labels (gummed paper labels or tags are adequate) must include the following information:

- Name of collector
- Date and time of collection
- Place of collection
- Collector's sample number, which uniquely identifies the sample.

A suitable sample numbering system will be developed by the sampling team and laboratory once the investigation commences. The system will be approved by Clement Associates.

E. Sample Seals

Sample seals are used to preserve the integrity of the sample from the time it is collected until it is opened in the laboratory. Gummed paper seals may be used for this purpose. The paper seal must include, at least, the following information:

- Collector's name
- Date and time of sampling
- Place of collection
- Collector's sample number (identical with the number on the sample).

The seal must be attached so that it is necessary to break it in order to open the sample container.

F. Field Log Book

All information pertinent to a field survey and/or sampling must be recorded in a log book. This must be a bound book, preferably with consecutively numbered pages that are 21.6 by 27.9 cm (8.5 by 11 inches). Entries in the log book must include at a minimum, the following:

- The sampler's name and address
- The sampling methodology
- A brief description of the sample material
- Relevant observations (odors, colors, moisture, etc.)

- The sampling location or, for groundwater samples, well number that the sample was withdrawn from
- A description of the sampling location
- References such as maps or photographs of the sampling site.

Sampling locations should be reported with an accuracy of 1 foot.

G. Chain of Custody Record

To establish the documentation necessary to trace sample possession from the time of collection, a chain of custody record must be filled out and accompany every sample. This record is essential if the sample is to be introduced as evidence in litigation:

- Collector's sample number
- Signature of collector
- Date and time of collection
- Place and address of collection
- Tenure of possession
- Signatures of persons involved in the chain of possession
- Inclusive dates of possession.

H. Sample Quality Control/Quality Assurance

Sample duplicates and field blanks will be collected to assure the quality of the field sample collection program. The frequency of duplicate and blank collection will be determined by the analytical laboratory subject to approval by Clement Associates.

I. Sample Analysis

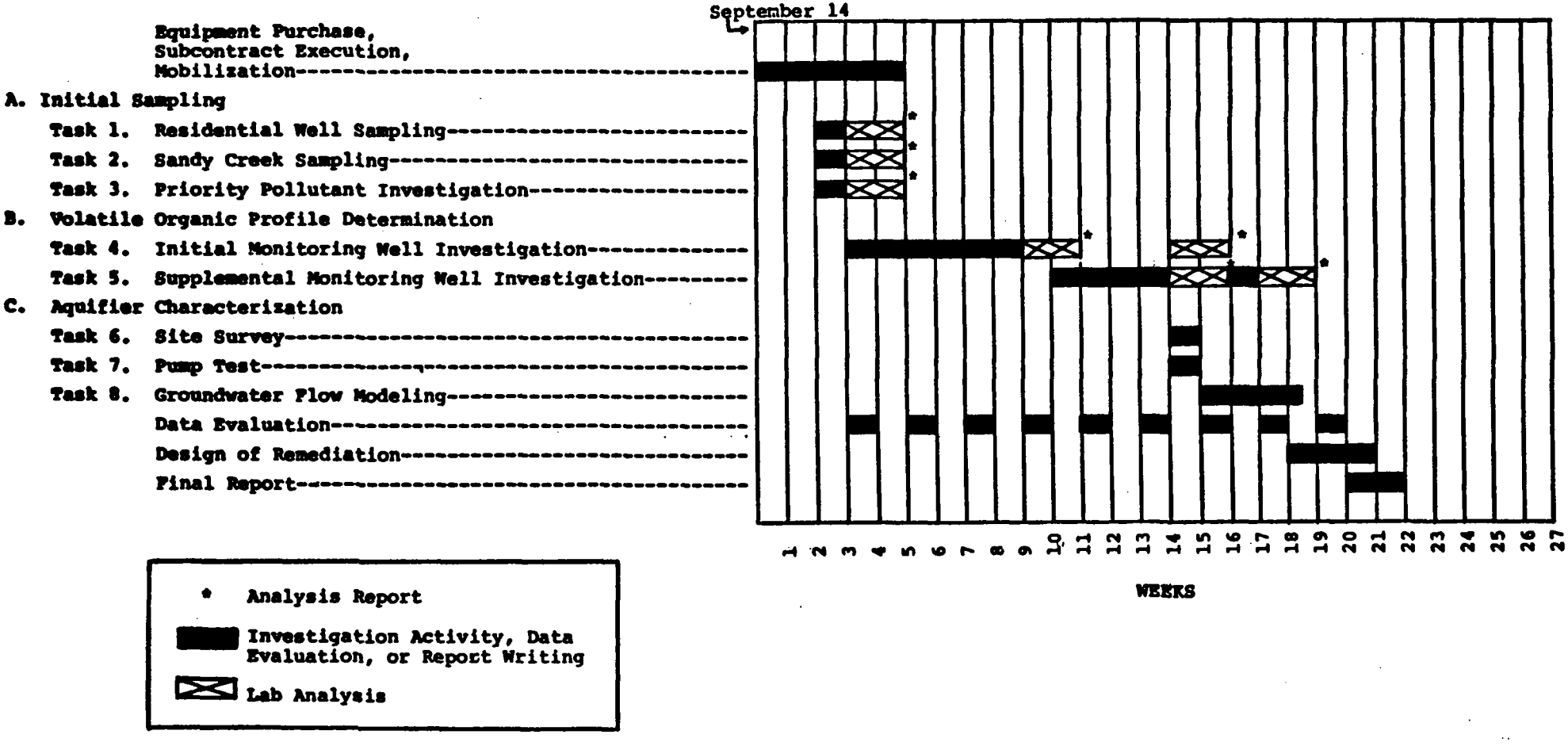
Analyses will be performed by a qualified laboratory using USEPA approved methodologies for sample analyses as outlined in "Test Methods for Evaluating Solid Wastes" (USEPA SW-846, 1982).

APPENDIX B

A preliminary schedule for the proposed feasibility study is presented in the attached Figure B-1. The proposed work tasks and design of the proposed groundwater treatment system are expected to require 13 weeks to complete. It is not anticipated that this work will cause any delays on the proposed remediation program schedule as currently envisioned.

FIGURE B-1

SCHEDULE FOR PROPOSED FEASIBILITY STUDY



APPENDIX C

Well specifications and procedures for well installation, sampling, and development are provided below.

Well Installation

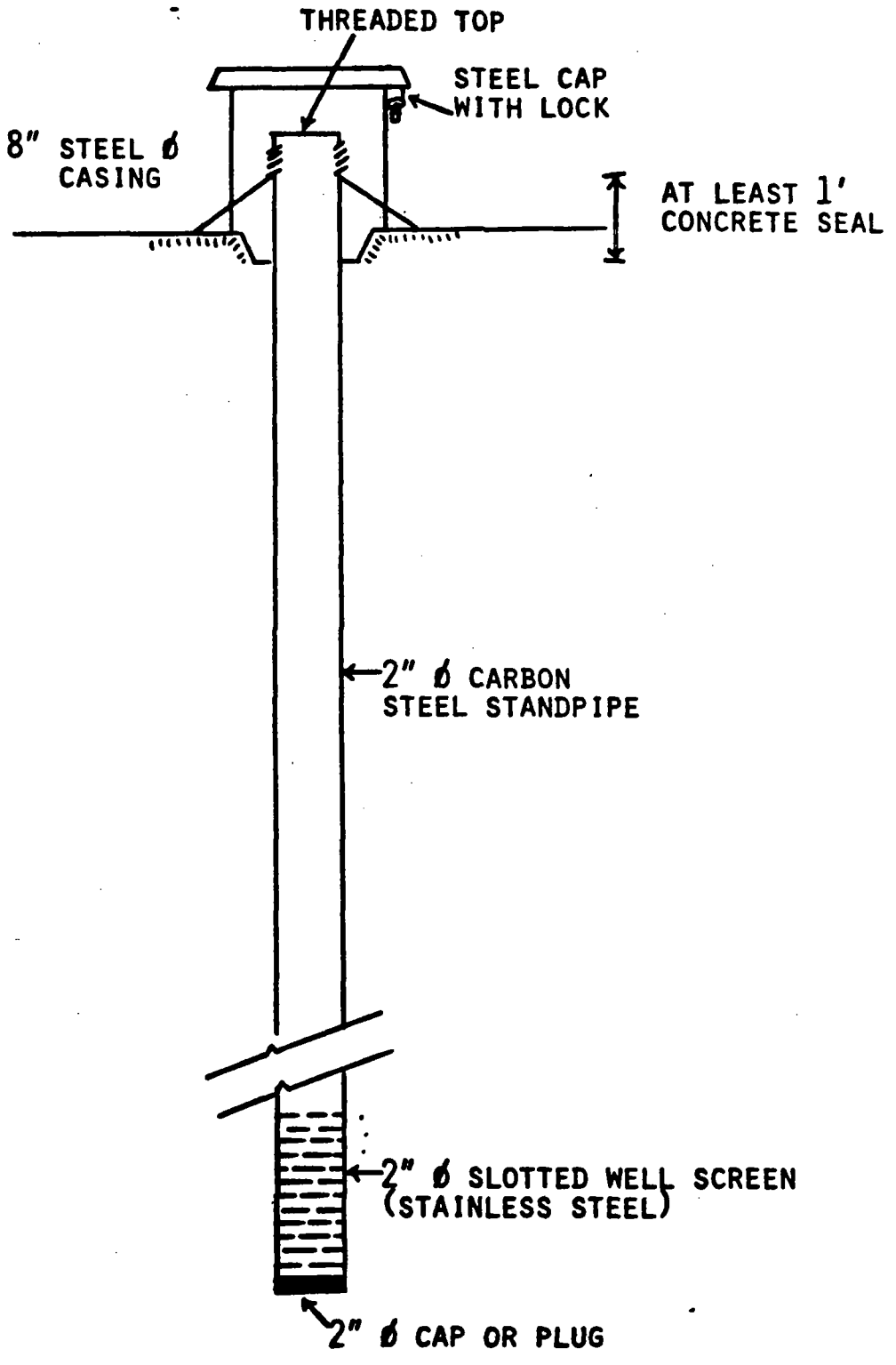
All wells (single and multi) will be advanced by the hollow rod method, a variation of the cable tool (driven casing) method. In this method, a casing (nominal 3-inch steel) is first driven to a specified depth and is drilled out with a hollow rod rather than cable tool. The hollow rod is attached by pipe to the surface and equipped with a check valve which is open on the downstroke and closed on the upstroke. When used in this manner, the hollow rod acts as a piston pump and local formation water is drawn through the rod carrying formation solids with it. Thus, external water need not be added to the well. Prior to initiation of drilling activities, the drilling area will be cleared of vegetation and the first foot of soil will be removed within a 2-foot radius to minimize the potential for introducing surface contamination into the borehole during drilling. Formation samples will be collected in multi wells for every new casing length, approximately 7 feet, and at every major change in formation encountered during borehole advancement. Formation samples will be collected by advancing a clean sample taker beyond the casing and withdrawing the sample taker prior to subsequent advancement of the casing. Samples will be sealed in glass jars and stored for future analysis. In addition,

a duplicate sample of each major type of formation encountered during borehole advancement will be collected and stored for future geophysical analyses. Samples stored for future analyses will be hermetically sealed to minimize moisture loss in storage.

Well Specifications

Casing used for borehole advancement will be nominal 3-inch O.D. Once borehole advancement is complete, a nominal 2-inch O.D. standpipe and well screen will be installed for final well development. The screen length and placement (depth) will be determined for each well by Clement Associates based on results of earlier phases of the well monitoring program. Well standpipes will be constructed of carbon steel and screens will be constructed of stainless steel. Well casing lengths and screens will be connected using threaded and coupled joints. The bottom of the well screen will be sealed with a threaded cap or plug. Due to the minimal size of the annular space surrounding these wells, the local formation is expected to heave sufficiently as the drilling casing is removed to obviate the need for grouting the wells. Wells will be sealed and immobilized with a concrete cap as indicated in Figure 3. The concrete cap will also serve as the foundation for a protective steel casing and locking cap to be placed over the top of the well (see Figure C-1). Single and multi well specificatons are identical.

FIGURE C-1
SCHEMATIC MONITORING WELL CONSTRUCTION FOR THE PROPOSED NEW WELLS AT THE TRW SITE IN MINERVA, OHIO



NOTE: GROUTING MAY BE NECESSARY ABOVE THE SEASONAL AVERAGE WATER TABLE SURFACE.

Groundwater Sample Collection from Multi Wells

In addition to formation samples, groundwater samples will be collected at approximately 13-foot depth intervals (two casing lengths) during advancement of multi wells. The following procedure will be used for collection of groundwater samples. After the formation sample taker is removed, a nominal 3-inch well screen (one 7-foot length section) will be placed to the bottom of the casing and the casing will be pulled back to expose at least 3 feet of screen. A clean suction hose (polyethylene or equivalent) will then be lowered several feet beyond the standing water level in the casing and at least ten casing volumes of water will be withdrawn at a pumping rate between five and fifteen gallons per minute. Additional water will be withdrawn, if necessary, until the water runs clear. The suction hose will then be withdrawn, and the groundwater will be allowed to equilibrate in the well (the water level must be allowed to return to within six inches of the nominal level detected at the start of this procedure). Three water samples will then be withdrawn from the well with a clean bailer. All samples will be transferred to clean glass jars and preserved as prescribed in protocols for volatile organic analyses.

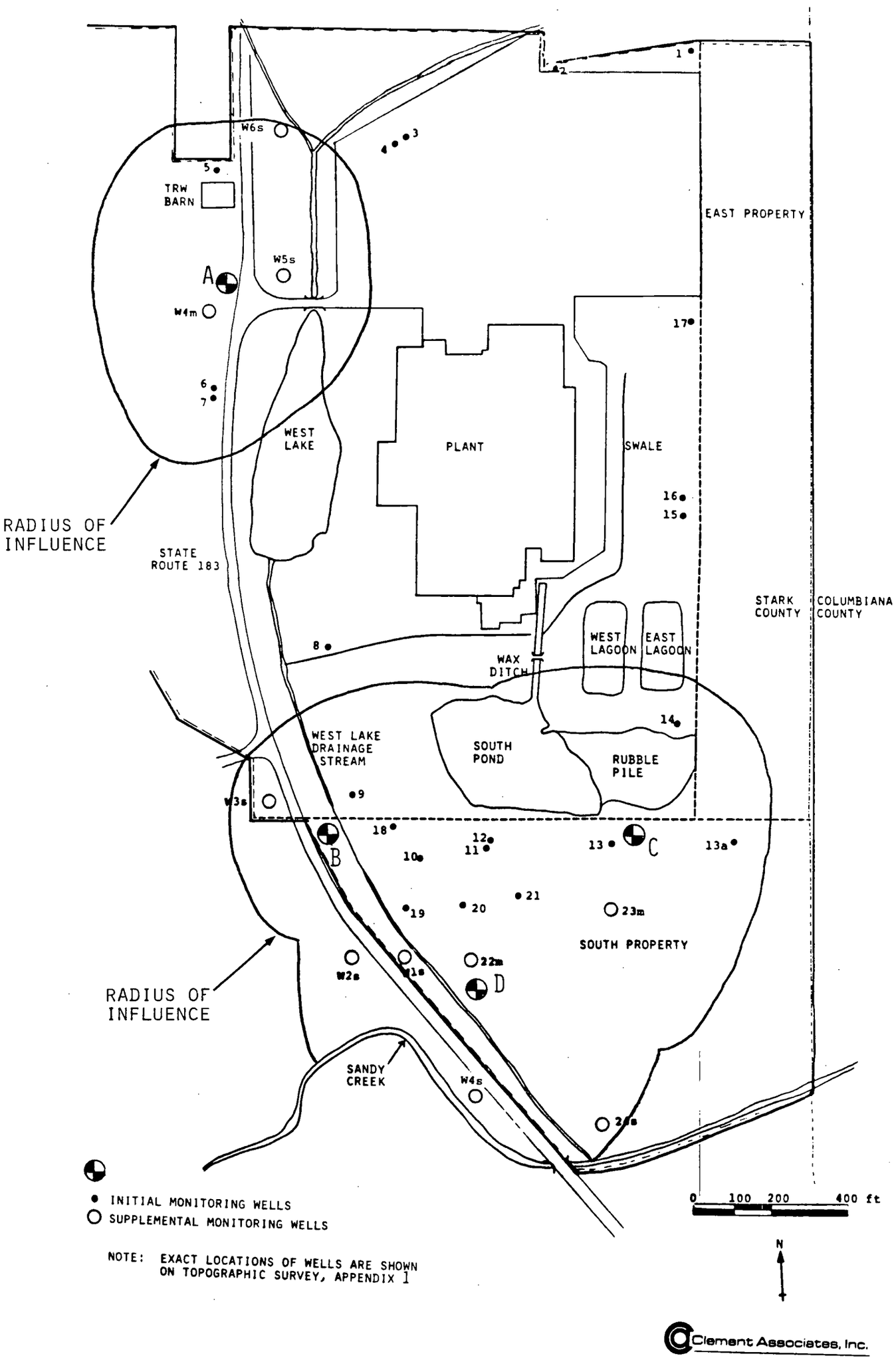
When groundwater sample collection has been completed for a particular depth, the casing will be relowered to the original position and the well screen will be withdrawn from

the well. In order to prevent upwelling of solids in unconsolidated deposits, it may be necessary to add a small quantity (less than five gallons) of laboratory water to the casing to maintain a positive hydrostatic head while the screen is removed.

Single wells will be advanced as prescribed above except that formation samples and groundwater samples will not be collected during borehole advancement.

FIGURE 23

APPROXIMATE LOCATIONS OF PROPOSED WITHDRAWAL WELLS AND RADII OF INFLUENCE, TRW SITE, MINERVA, OHIO



NOTE: EXACT LOCATIONS OF WELLS ARE SHOWN ON TOPOGRAPHIC SURVEY, APPENDIX I

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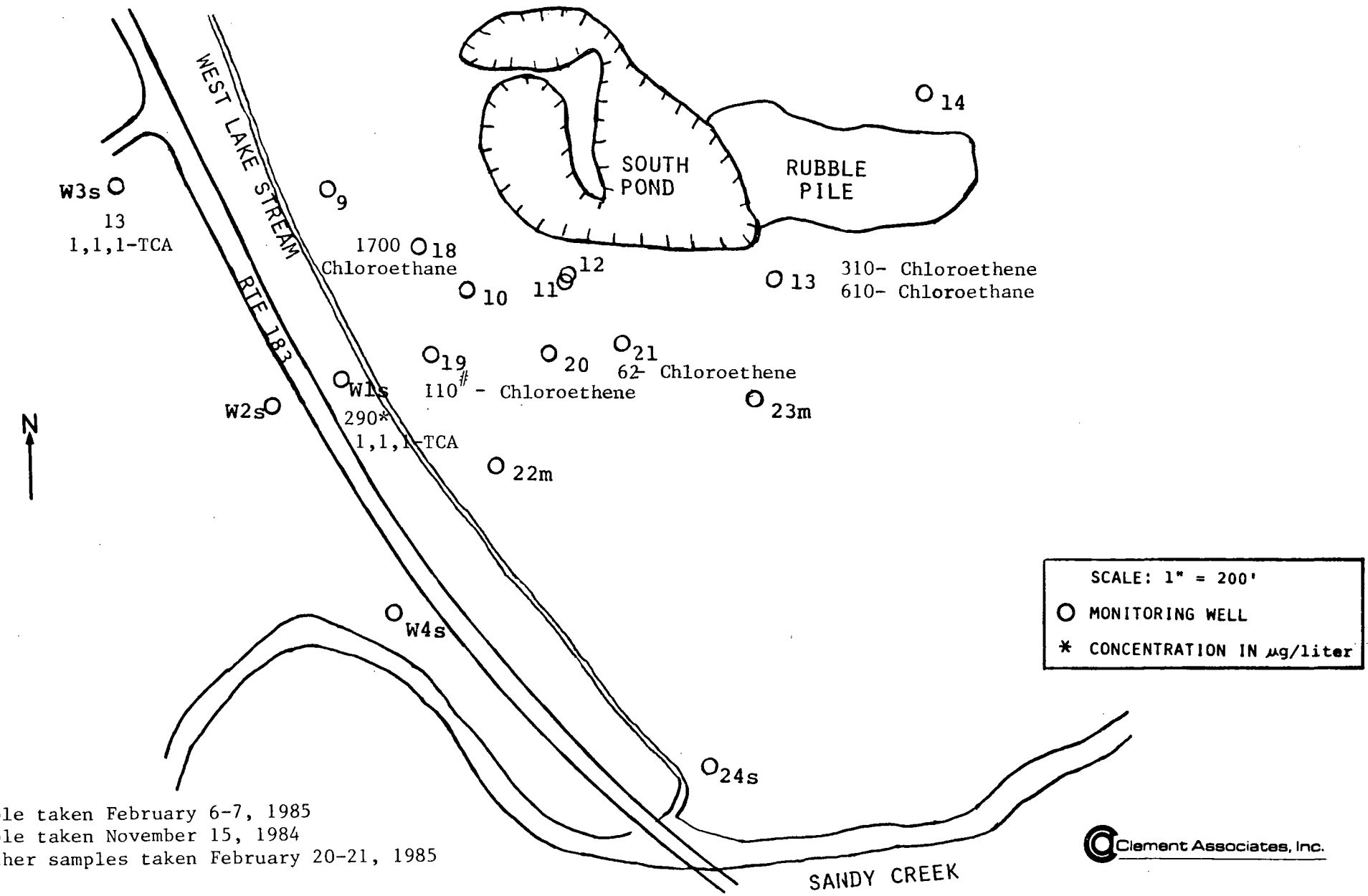
FIGURE 17

CONCENTRATION OF THREE CHEMICALS IN GROUNDWATER AT THE TRW SITE, MINERVA, OHIO



* Sample taken February 6-7, 1985
\# Sample taken November 15, 1984
All other samples taken February 20-21, 1985

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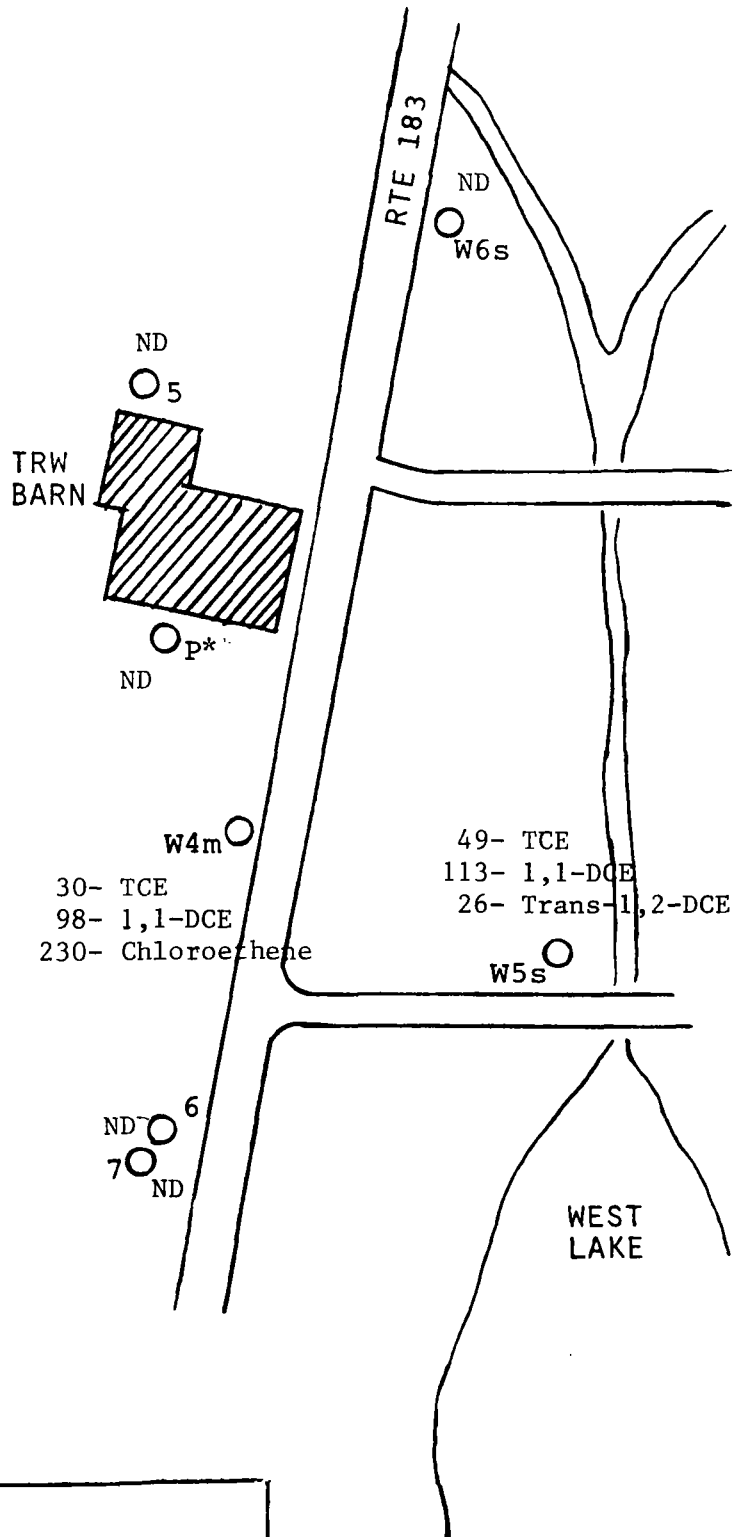
FIGURE 18

CONCENTRATION OF UNSATURATED VOLATILE ORGANICS IN THE BARN AREA, TRW SITE, MINERVA, OHIO

(Concentration in µg/Liter)



SCALE: 1" = 100'

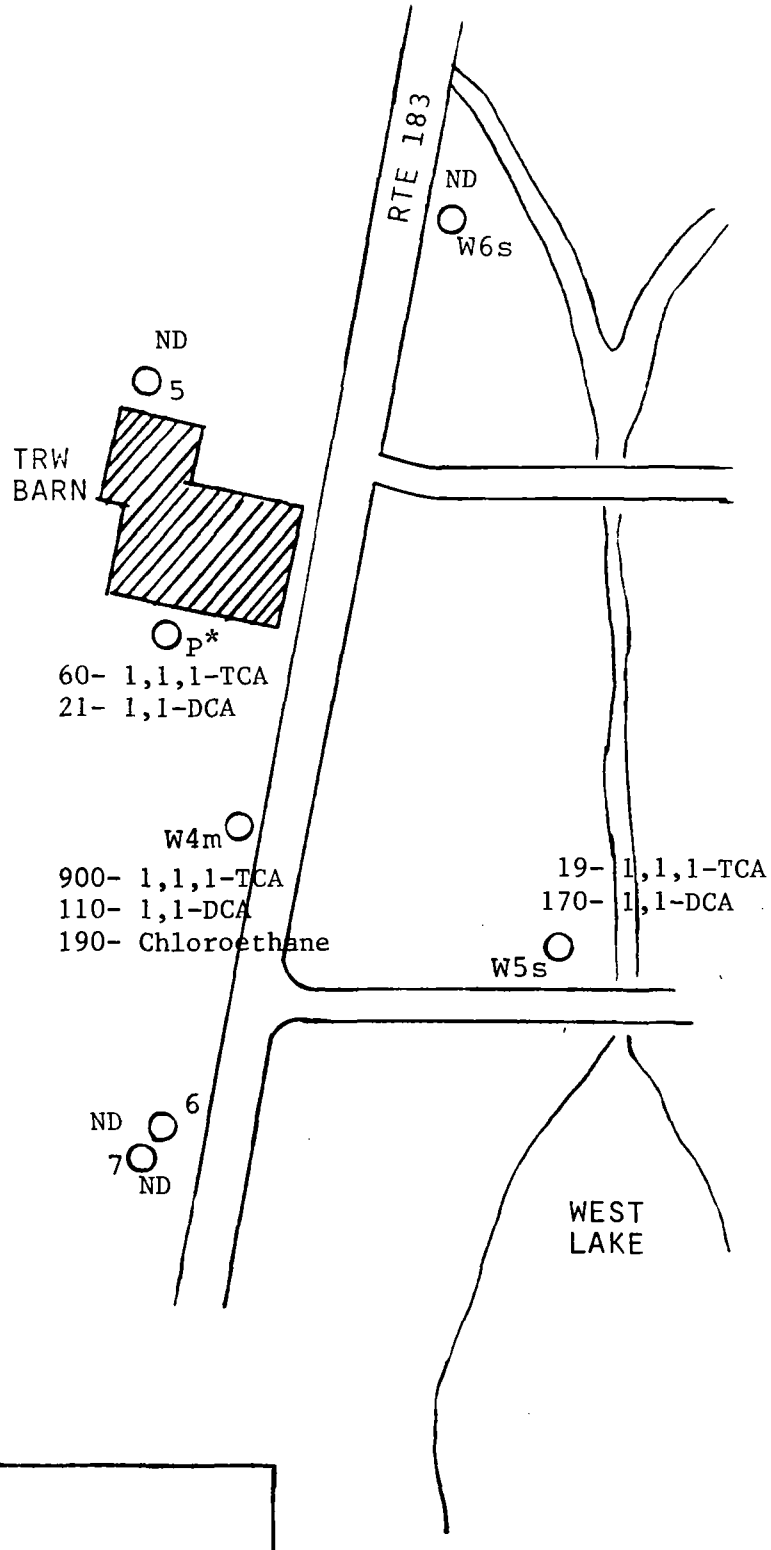
O Monitoring Well
P TRW Production Well
ND Not Detected
* Sampled October 1984
All Other Samples Taken February 20-21, 1985

Clement Associates, Inc.

FIGURE 19

CONCENTRATION OF SATURATED VOLATILE ORGANICS IN THE BARN AREA, TRW SITE, MINERVA, OHIO

(Concentration in µg/liter)



N

SCALE: 1" = 100'

- ○ Monitoring Well
- P TRW Production Well
- ND Not Detected
- * Sampled October 1984

All Other Samples Taken February 20-21, 1985

Clement Associates, Inc.

of this contamination (either South Pond or the wax ditch) has been depleted and is no longer contributing to this plume. The second plume centers around well 13 and is primarily 1,1-DCA. The source of this plume does not appear to have been depleted.

3. Based on the results of groundwater samples taken during drilling contaminants are restricted to the upper 20 feet of groundwater.

4. The movement of contaminants south of the plant corresponds well with the groundwater flow.

5. Several contaminants (particularly TCE and trans-1,2-DCE) may have reached Sandy Creek. This is indicated by the relatively high concentrations detected in well W4s. It is believed that these contaminants are either volatilized or diluted by the stream flow so that they are not detectable in the creek. Note that the samples collected from Sandy Creek (including one collected at the expected point of plume discharge) exhibited no detectable concentrtaions of volatiles.

6. It is unknown whether contaminated groundwater can cross Sandy Creek and continue to flow southward. Although there are no wells south of the creek to test this possibility, it is not unreasonable to expect that the creek serves as a barrier to contaminant migration. This will be investigated further.

7. The contaminant plumes detected south of the plant are not related to the volatile contaminants found in the Old Park residential areas. This conclusion is drawn both from

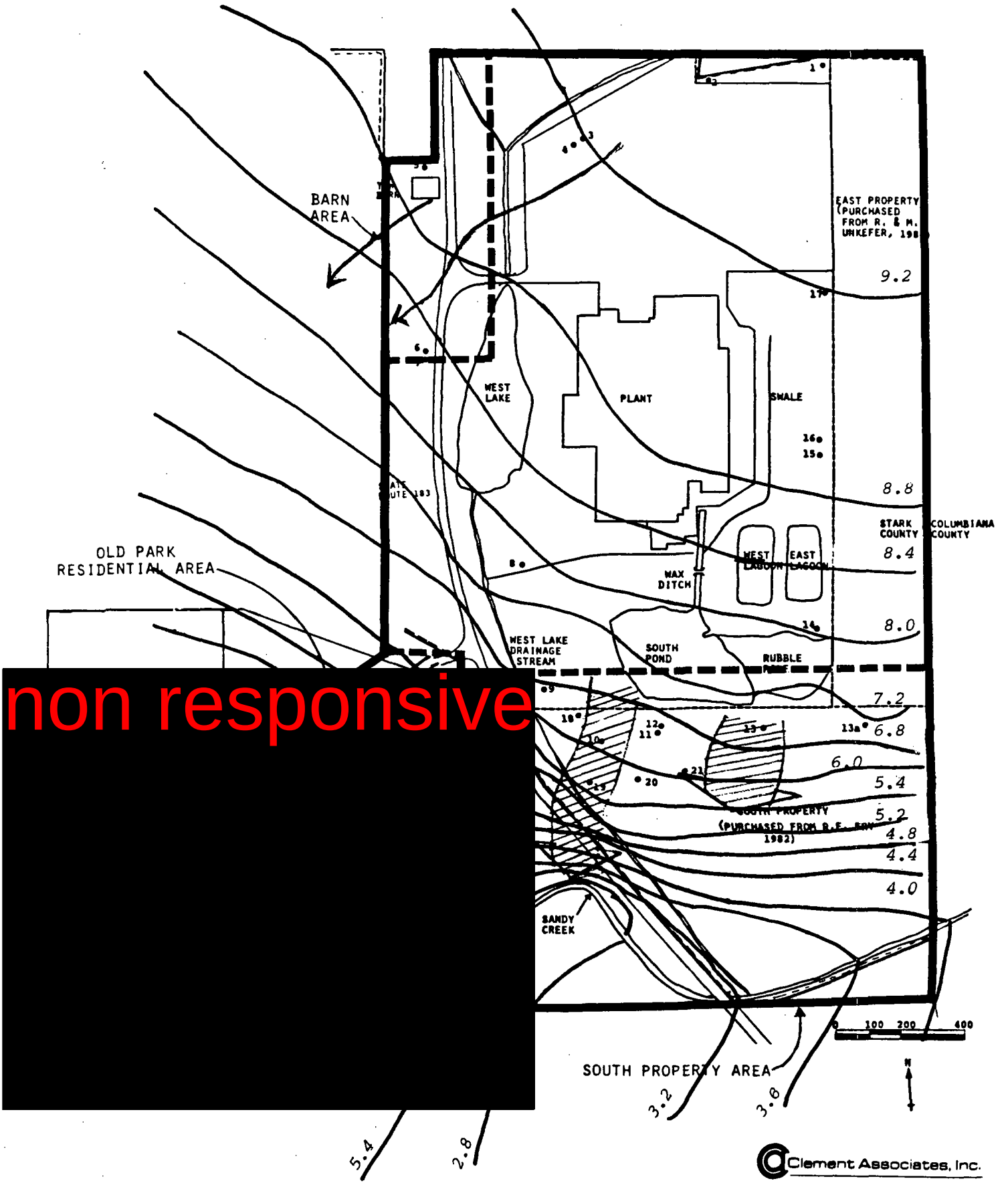
flow analysis and constituent analysis. Based on the direction of groundwater flow, as indicated in Figure 20, volatile organics detected on the southern portion of the TRW property will not impact the Old Park Residential Area except, possibly, the extreme southwest corner.

Analysis of the distribution of volatile organics in groundwater at the site also indicates a lack of association between contaminants detected on site and those detected in the Old Park Residential Area. This is demonstrated by considering the source and chemistry of the constituents present. Figure 21 presents a profile of unsaturated constituents detected as a function of distance downgradient in groundwater at the TRW site. This needs to be compared with groundwater analyses in the Old Park Residential Area where chloroethene is the principal constituent and there are only traces of TCE and PCE. Although not shown in Figure 21, the data in Table 1 show only sporadic detection of chloroethene at the TRW site.

Because there is no record of DCE use at the site, and typical of other sites where TCE is present in groundwater, DCE is believed to be a product of the anaerobic biodegradation of TCE. At sites where this process has been documented, the concentration of DCE increases relative to TCE downgradient of the source because biodegradation is believed to occur in the groundwater regime and the materials farthest downgradient would have been subjected to this process the longest. Based

FIGURE 20

DIRECTION OF GROUNDWATER FLOW IN AREAS OF KNOWN CONTAMINATION AT THE TRW SITE, MINERVA, OHIO

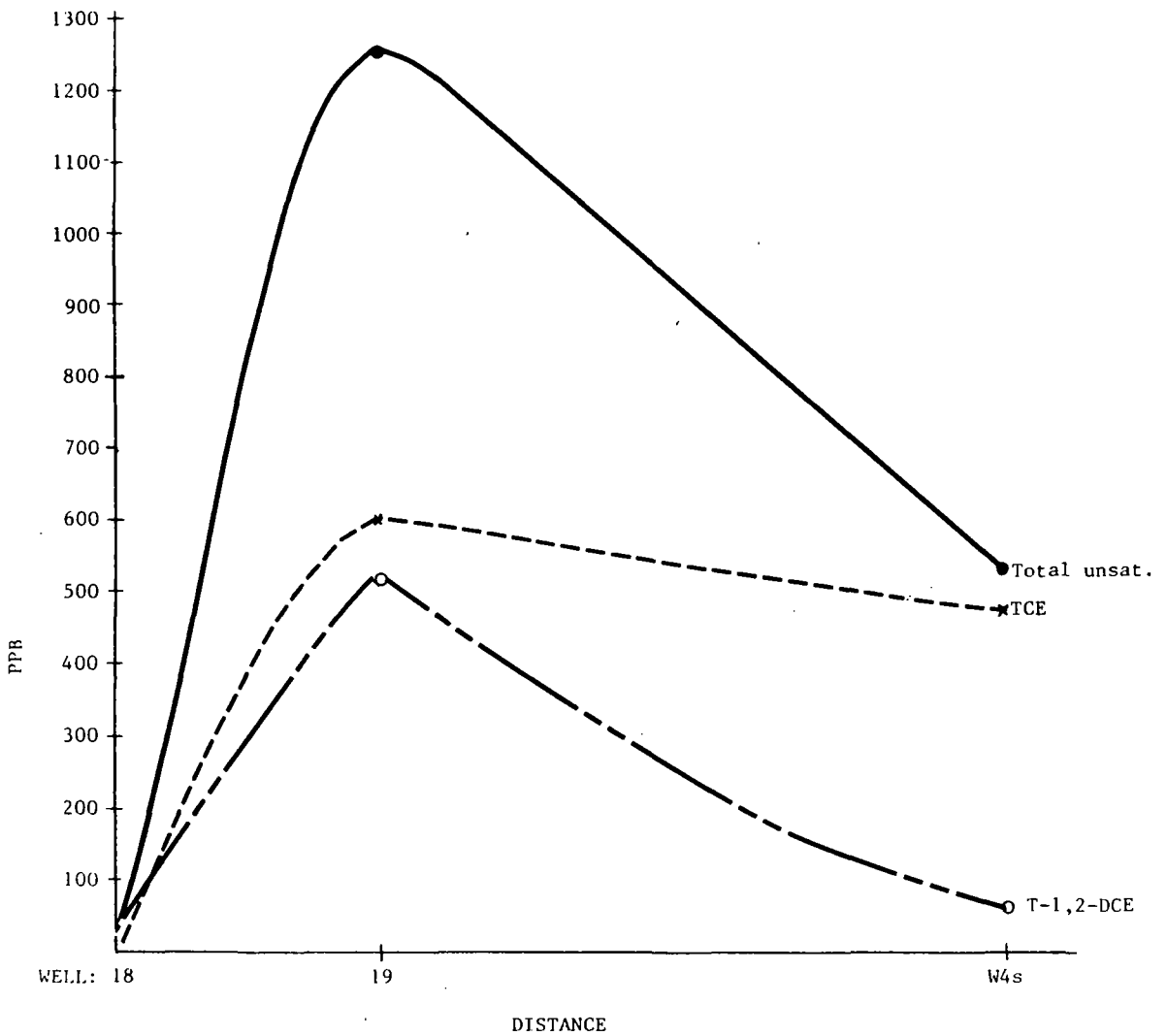


non responsive

Clement Associates, Inc.

FIGURE 21

RELATIVE CONCENTRATIONS OF TCE AND TRANS-1,2-DCE
IN GROUNDWATER SOUTH OF THE TRW PLANT



Clement Associates, Inc.

on Figure 21, however, the concentration of TCE increases relative to DCE at increasing distances downgradient. This suggests biodegradation is occurring at the source rather than in the groundwater regime so that materials present at the source the longest (the most upgradient constituents) are more fully degraded. Since chloroethene likely represents a biodegradation product of DCE in a similar manner, one would expect to see chloroethene only in the immediate vicinity of the source at the TRW site. Therefore, the concentration of constituents present in the Old Park area (consisting largely of chloroethene) does not match the composition of volatile organic constituents detected at the TRW site nor does it follow the trend in composition expected for volatile organics migrating from the site.

8. The source of contamination in the Old Park Residential Area is unknown at this time.

9. Contamination in the barn area does not show any consistent pattern, and the source of this material is subject to question. Contaminant levels are generally lower in well W5s than in well W4m, however, this is contrary to what would be expected if a source existed in the vicinity of the barn. In addition, the direction of groundwater flow in this area suggests that a source would likely be located northwest of the barn, but wells further upgradient are clean. Further investigation may be necessary to understand the source and distribution of contamination in this area.

10. Although Sandy Creek is believed to act as a contaminant barrier, this hypothesis has not yet been demonstrated. Therefore, it is unknown whether contamination may move under Sandy Creek and continue southward. Further investigation may be useful to investigate this possibility.

11. Although minor uncertainties remain as to the exact distribution of groundwater contamination at the TRW site (as discussed above), the current data base was sufficient to design a well withdrawal field which would effectively capture all existing contamination and preclude further migration.

Application of Preliminary Technologies

This groundwater remedial investigation has delineated the distribution of contamination sufficiently to design a remedial alternative that will control the migration of contaminants offsite. Remaining, minor uncertainties may be resolved by further investigation, if such data are deemed necessary to successfully complete remediation at the site.

Task 5. Final Report

This report constitutes the final report as required under Task 5 of the Ohio EPA Generic RI/FS Statement of Work.

Task 6. Additional Requirements

a. Reporting Requirements

Since remedial investigations at the site have been completed, the question of monthly progress reports is moot.

b. Chain-of-Custody

Appropriate chain-of-custody protocols were outlined in the work plan developed for the TRW site (Appendix 1). The custody of samples collected at the site was properly documented from collection through analysis.

c. Quality Assurance/Quality Control (QA/QC)

Quality assurance/quality control requirements were considered during all phases of the TRW site investigation for both laboratory and field work. Field QA/QC procedures relied heavily on the proven performance of adopted protocols. Sample collection, handling, storage, transport and analysis protocols that were recommended by USEPA, OEPA, or other government agencies were used when appropriate. If procedures were required for which established protocols could not be adopted, procedures with reported track records in the literature were preferred to the development of new procedures.

All procedures were specified in detail to insure smooth communication and coordination between Clement Associates and the sampling team (usually from Alert Laboratories). The representativeness, integrity, and reproducibility of field practices were monitored through a combination of field blanks, duplicates, and more importantly, analyses of the pattern of results over a large number of samples from a given area. Strict chain-of-custody procedures were followed during the transport and handling of all samples.

QA/QC for laboratory procedures was also maintained with the analysis of a series of lab blanks, duplicates, and spikes. Sampling work plans specified the specific analyses to be performed, established protocols to be used in the analyses, and identified the desired limits of detection for each batch of samples collected for analysis. The procedures for calibration, the frequency of QC checks, the protocols used in analysis and sample handling, and the general QA/QC management philosophy of the chosen laboratory were summarized in previous documents (Clement 1984b).

III. FEASIBILITY STUDY

Task 7--Description of Current Situation

The current situation is described in Task 1 of the Remedial Investigation.

Task 8--Development of Alternatives

a. Establishment of Remedial Response Objectives

The objective of the remedial response is to reduce or eliminate the potential for off-site migration of the volatile organics found in the groundwater on site. This will reduce or eliminate potential health risks identified in earlier risk evaluations of groundwater contamination at the TRW site (Clement 1984a). This objective is derived from the results of the current remedial investigation and the earlier risk evaluations. Because the proposed groundwater remediation will be conducted in conjunction with comprehensive surface remediation at the site, source control measures are not addressed as part of the groundwater remediation program.

b. Identification of Remedial Technologies

Remedial technologies that were considered for the TRW site are listed in Figure 22. The technologies can be divided into four basic categories: (1) no action, (2) in situ treatment (3) containment and (4) removal and treatment.

c. Identification of Remedial Alternatives

Many of the remedial technologies listed above were eliminated in a preliminary screening based on lack of technical

FIGURE 22

REMEDIAL TECHNOLOGIES
FOR THE TRW SITE IN MINERVA, OHIO

No Action

In-Situ Treatment

- Aerobic biodegredation
- Anaerobic biodegredation
- Permeable beds

Containment

- Upgradient slurry well
- Downgradient slurry well

Removal

- Trenches
- Well withdrawal system

→ Treatment

- Off-site (Hazardous waste disposal)
- On-site
  - -Activated carbon
  - -Air stripping

reliability or inappropriateness for the TRW site. The "no action" alternative was eliminated because it would not meet the objectives of reducing the potential for future off-site groundwater contamination.

The in situ treatment techniques were also eliminated. Aerobic biodegradation involves the introduction of air into the groundwater to stimulate the growth of aerobic microorganisms which consume the organic matter. The technique, however, is used mainly for hydrocarbon spills and has been shown not to work effectively on chorinated organics (USEPA 1982). Similarly, anaerobic treatment involves the introduction of methane or propane into the soil to enhance the growth of anaerobic microorganisms to consume the contaminants. This technique is still in its experimental stages and cannot be considered a reliable technology at this time (Wilson and Wilson, 1985).

Permeable beds is a technique that requires the placement of a wall of permeable material such as limestone, activated carbon or sand perpendicular to the groundwater flow. The bed acts as a filter, removing the contaminants as the groundwater passes through. Limestone and sand are only effective in removing metals and are therefore not appropriate for this site. Although activated carbon will adsorb volatile organics, the breakthrough times for some compounds are relatively low. This would mean that a large quantity of material would be required; thereby making this alternative impractical.

Containment techniques were also eliminated as inappropriate

for this site. Although slurry walls--either of clay, grout of sheet piling--are reliable technologies, hydrogeologic conditions at the site make them impractical. In general, slurry walls need to be tied to bedrock or an impermeable layer. The depth to bedrock at the site is between 90 and 150 feet. The maximum depth that a slurry wall can be constructed is approximately 60 feet. The technique is therefore impractical.

Based on this preliminary screening, the following alternatives remained to be evaluated in detail.

Removal

- Trenches
- Well withdrawal system

Treatment

- Off-site disposal
- On-site treatment via activated carbon
- On-site treatment via air stripping

The alternatives require both removal and treatment technologies.

Task 9--Initial Screening Alternatives

The initial screening of alternatives is presented in Task 8.

Task 10--Laboratory Studies

Pilot plant studies are often used in the design of both activated carbon and air stripping systems. However, much design information is also available in the literature. It is believed at this time that the literature information is

adequate to enable a treatment system design for this site. Pilot studies or other laboratory studies are therefore not considered necessary at this time.

Task 11--Detailed Analysis of Alternatives

The alternative that remained after the preliminary screening were evaluated based on their reliability in terms of standard engineering practice, environmental impact, and cost. Groundwater removal systems were evaluated separately from treatment systems.

Trenches for the removal of groundwater require placement of a drain pipe in an excavation that is backfilled with permeable material such as gravel. The technique is reliable and extensively used. If properly designed and installed a trench system should effectively allow the removal of all contaminants. The alternative would not result in adverse environmental impacts other than the temporary impacts associated with construction. However, due to the soil conditions at the site, trenches are expected to be difficult to implement and a high cost alternative. Excavation to the required depths (40-50 feet) would require extensive dewatering and sheet piling to prevent cave-in. Further, pumping would still be required to remove the groundwater from the trench system, resulting in an additional cost.

Like trenches, withdrawal wells are a reliable, extensively used system. The groundwater modeling detailed in Appendix 9 indicates that properly installed and operated wells should

be effective in removing contaminated groundwater for treatment. No adverse environmental impacts, other than temporary impacts due to well drilling activities, are anticipated from a well withdrawal system. The well withdrawal system is estimated to be a less costly system than trenches. The proposed well system would require the drilling of four wells (three south of the plant and one in the barn area) and the installation of pumps and appurtenant piping. Since the groundwater removal system will be temporary, the pumps and piping should retain a high salvage value.

Off-site disposal of the contaminated groundwater represents a reliable treatment alternative assuming that a suitable disposal site is available. However, this alternative must be considered difficult to implement and costly. Because of the types of contaminants present, the groundwater would have to be treated as a hazardous waste, entailing waste manifesting and costly disposal. Additional costs would be incurred in providing temporary storage and in transportation. The increased truck traffic would have a significant impact in the area in terms of noise, traffic, and potential accidents.

The use of granular activated carbon as a treatment method for contaminated groundwater has long been accepted by EPA. The technology can be considered reliable and easily implemented and would not result in any adverse environmental impacts. Recent studies, however, have indicated that for chlorinated volatile organics, activated carbon treatment may be a costly

alternative. Breakthrough times for volatiles may range from 10 days for vinyl chloride to 100 days for trichloroethane (Environmental Science and Engineering, Inc., 1980). This means that the carbon would need to be regenerated or replaced frequently resulting in high capital and operating costs. If the carbon is to be regenerated the disposal of the flushate represents an additional cost.

Air stripping is a technology that has been extensively used in water treatment for the removal of volatile organics. The process involves passing the contaminated water through either a series of trays, or a section of packing where air is brought in contact with the water. Alternatively, air may be bubbled through a column of the contaminated water. The contaminants are transferred from the water to the air and are discharged to the atmosphere. The process is reliable and easily implemented. Air stripping will not result in adverse environmental impacts. It is estimated that the air stripper will discharge approximately 3.4 pounds of hydrocarbons per day (D. Van Arnam, O'Brien and Gere, enclosures to letter to C.T. Bingham April 3, 1985). This will have a negligible impact on air quality. Pilot studies have shown that air stripping is a relatively low cost process. For the removal of volatile organics, the cost may be as low as 25% of the cost of treatment with activated carbon (Environmental Science and Engineering, 1980).

Task 12--Evaluation and Selection of Cost-Effective Alternative

Based on the analysis presented in the previous section the most cost-effective remedial alternative is a well withdrawal system and treatment by air stipping. This alternative is reliable, easily implemented, does not result in any adverse environmental impacts and has a relatively low cost.

Task 13--Conceptual Design

The groundwater flow model described in Appendix 9 was used to simulate various well withdrawal systems. Approximately 75 different well configurations were modeled. From these, five optimum cases were selected. These configurations used either four wells (three south of the plant and one in the barn area) or five wells (four south of the plant and one in the barn area). Pumping rates ranged from 100 to 300 gpm at the barn and 50 to 100 gpm each south of the plant. The well configuration that is proposed for the site is shown in Figure 23. It consists of one 300 gpm pump near the barn area and three 100 gpm pumps south of the plant. The total pumping rate will therefore be 600 gpm. This is a conservative configuration designed to extend beyond areas of known contamination. It is believed that the flow rate can be reduced to approximately 400 gpm over time as the main areas of contamination are removed.

Influent concentrations for each well have been estimated and are presented in Table 5. These estimates are based on the assumed radius of influence of each pump and also assume a dilution factor of three, i.e., two parts of clean water

TABLE 5

ESTIMATED CONTAMINANT INFLUENT CONCENTRATIONS

Contaminant	Well	Initial Concentration (ppb)	Maximum Concentration (ppb)	Time to Maximum Concentration (days)
TCE	A	13	13	1
	B	0	6	500
	C	0	5	800
	D	183	183	1
Trans-1,2-DCE	A	4	4	1
	B	0	31	400
	C	200	200	1
	D	0	12	560
1,1-DCA	A	33	33	1
	B	17	48	400
	C	333	333	1
	D	0	19	400
1,1,1-TCA	A	67	67	1
1,1-DCE	A	35	35	1
Vinyl chloride	A	38	38	1
Total	all	217	217	1

will be withdrawn for every part of contaminated water. This is based on placing the pumps at a depth of 60 feet below the water table, whereas contaminants have only been detected in the upper 20 feet of the water table. The total initial concentration is estimated to be 217 ppb.

It is proposed that the treated groundwater be discharged to Sandy Creek, either directly or via the West Lake drainage stream. Currently, there are no federal or state effluent guidelines that regulate the discharge of chlorinated organics from a groundwater treatment system. The Ohio EPA has used a case-by-case approach for evaluating similar projects in the past. It is proposed that probable Maximum Contaminant Levels (MCL's) to be proposed by EPA and the dilution provided by Sandy Creek be used to determine the effluent concentration. EPA has suggested that MCLs for chlorinated organics may be set in the range of 5 to 50 ppb (49 FR 114 pp. 24348). Historic low flow in Sandy Creek is approximately 7 cubic feet per second (USGS 1982). This would mean that the creek at low flow would provide a dilution of 5:1 for the air stripper effluent at 600 gpm. If the target level to be achieved in Sandy Creek is set at the low range of the suggested MCL's (5 ppb) then the five-to-one dilution from the creek would allow an effluent concentration of 25 ppb. It is therefore proposed that the effluent discharge level be set at 25 ppb for total volatile organics. This represents and 88% reduction from the initial

maximum concentration. This is known to be within the technically feasible range for air stripper systems.

The preliminary design of the air stripping system is being undertaken by O'Brien and Gere Engineers, Inc., and will be presented in a separate report.

Task 14--Final Report

This report constitutes the final report as required under Task 14 of the Ohio EPA Generic RI/FS Statement of Work.

Task 15--Additional Requirements

Since the feasibility study has been completed, the question of monthly progress reports is moot.

APPENDIX 3

Attachments C and D from Drilling Contract

ATTACHMENT C

List of Potentially Hazardous Chemicals

Based on the best available data, potentially hazardous chemicals that may be present at the TRW site are:

PCBS:	Principally Aroclor 1254
Volatile organics:	1,1,1-Trichloroethane
	Trichloroethylene
	The Dichloroethanes
	The Dichloroethylenes
	and Vinyl Chloride

The work area, as defined in Figure 1b of Attachment A, actually consists of a narrow access strip leading from the decontamination station (on the wax ditch crossover) to drilling areas located on the south property. Significant concentrations of PCBs have been detected only in the small cross-hatched area running along the northern border of the South Property between wells 10 and 13. Even though surface soils in the remaining area are believed to be free of significant PCB or volatile organic contamination, for purposes of this contract, the entire work area will be considered to be contaminated and appropriate precautions will be followed accordingly.

ATTACHMENT D

Recommended Safety and Decontamination Procedures

Safety

All personnel who enter the work area, whether for supervision or performance of a specific work task, will wear the following protective equipment and clothing:

- Hard hat
- Safety goggles
- Inner reinforced work shoes
- Disposable outer rubber boots or equivalent
- A one-piece disposable tyvek splash suit or equivalent
- Disposable chemically resistant gloves
- Dust mask (optional)

Smoking, eating, or drinking will be prohibited while wearing protective clothing in the work area.

Upon leaving the work area at the decontamination station, workers will remove disposable items in a manner minimizing contact with the outer surfaces of the protective clothing. Clothing will be removed in the following order: splash suit, boots, and gloves. Used protective clothing wil be placed in an appropriately labeled 55-gallon drum equipped with a lid which will be located at the decontamination station.

Access

Access to the work area will be restricted to a single entry point at the decontamination station (which will be located on the wax ditch crossover). The route to be taken to get to or from the decontamination station, which avoids other potentially contaminated areas of the site, is outlined in Figures 1a and 1b of Attachment A. The route begins at the entrance to the TRW plant and proceeds east through the parking lot. The route then turns south and crosses the grassy field east of the plant. It is important to stay wide of the swale which runs along the eastern and southern border of the plant. The route then turns

southwest and passes on a narrow strip between the west lagoon and the swale and continues to the wax ditch crossover.

Access from the decontamination station to the drilling areas will be accomplished by demarcating a narrow strip of land (roughtly 10 feet wide) to run across the field west of South Pond, as indicated in Figures 1a and 1b of Attachment A. The path must pass wide of the South Pond area and out of the access gate in the fence. The path will then turn south and enter the south property drilling areas. Though no actual road exists, the access path indicated in Figure 1b will be demarcated by stakes and equipment traversing the path will stay within the flagged area to minimize the potential spread of contamination.

Decontamination Station

The subcontractor will be responsible for setting up the decontamination station and decontaminating all equipment leaving the work area. The decontamination station will be equipped with labeled 55-gallon drums to dispose of protective clothing and other potentially contaminated garbage. It will also be equipped with a high pressure hot-water spray and a methanol spray. The station will be designed in a manner so that waste washes and rinses drain into the wax ditch.

Decontamination Procedures

All drilling and clearing equipment will be cleaned with noncirculating water and methanol as follows:

(1) The equipment will be sprayed with high-pressure hot water to remove all dirt and other materials stuck to metal parts.

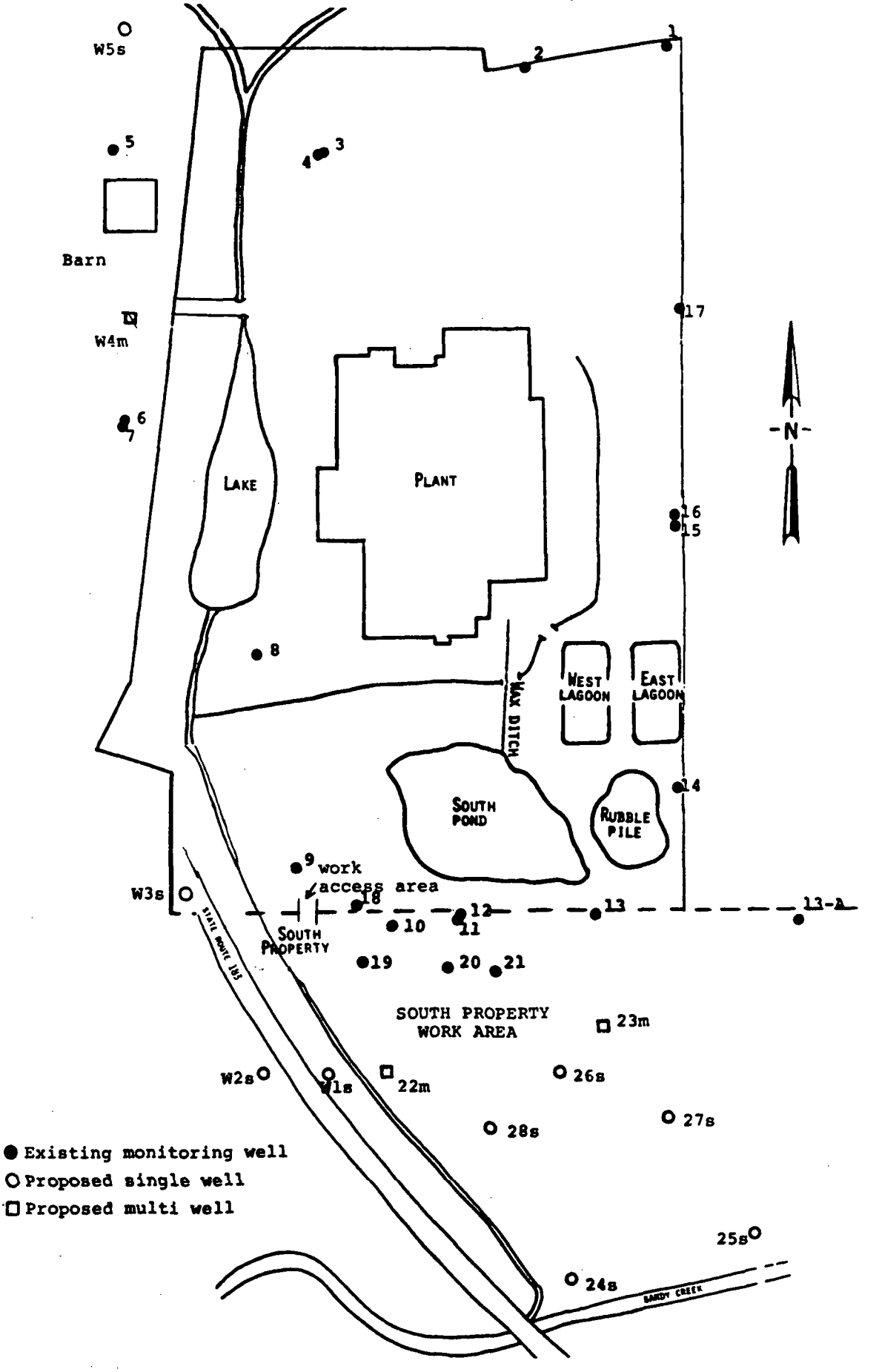
(2) The equipment will then be rinsed liberally with a methanol spray.

(3) Finally, the equipment will be rinsed thoroughly a second time with a hot water spray.

All waste water and methanol will drain into the wax ditch. All wastewater, mud, cutting, or other materials generated during

drilling will be collected and deposited in South Pond. No equipment will be removed from the work area without first being decontaminated in accordance with the above procedures.

FIGURE 2
PROPOSED LOCATIONS FOR NEW MONITORING WELLS
TO BE PLACED AT THE TRW SITE IN MINERVA, OHIO



APPENDIX 4

Owners and Locations of Residential Wells Tested

KEY

SAMPLING SUMMARY
"OLD PARK" RESIDENTIAL WELLS
NORTH OF THE BIG SANDY CREEK

Reference Dwg.
SK-100
10/26/84 Rev. 1

Well	1ST SAMPLE	2ND SAMPLE
1	-	-
2	-	-
3	9/11/84	-
4	11/6/84	-
5		-
6	-	-
7	9/11/84	11/6/84
8	9/11/84	-
9	11/6/84	-
10A	9/11/84	11/6/84
10B	11/6/84	-
11	11/6/84	-
12	-	
13A	11/1/84	-
13B	9/11/84	11/1/84
14A	9/11/84	11/6/84
14B		
15A	9/11/84	11/6/84
15B		
16A	11/1/84	-
16B		
17A	9/11/84	11/1/84
17B		
18	9/11/84	-
19A	9/11/84	11/1/84
19B		
20	11/1/84	-
21	9/11/84	11/1/84
22	-	-
23	9/11/84	11/1/84
24	-	-
25	-	-
26	9/11/84	11/6/84
27		

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APPENDIX 5

Letter from TRW to Stark County Health Department

TRW Aircraft Components Group
23555 Euclid Avenue
Cleveland, OH 44117

January 18, 1985

Stark County Health Department
Water Analysis Department
209 Tuscarawas Street, West
Canton, Ohio 44702

Gentlemen:

Per my letter dated December 18, 1984, TRW has undertaken the sampling of residential wells in the Old Park Area southwest of its Minerva facility as part of a site investigation. Due to inconsistencies in the data reported earlier, however, several residential wells were resampled. Resampling has now been completed and the results, along with results of the earlier sampling, are presented in the attached table. Samples were collected and analyzed by Alert Laboratories, Inc., Canton, Ohio.

Results summarized in the attached table indicate that volatile organics are present in samples collected from several wells in the Old Park Area. Although the data has been somewhat inconsistent, the most recent resampling confirms earlier analyses. Upon resampling, eight of the nine wells that had previously shown low levels of vinyl chloride exhibited vinyl chloride in concentrations between 2 and 16 ug/liter. The ninth well is no longer in service as the residence is now on the city water system. The presence of traces of other volatile organics (including 1,1,-trichloroethene, 1,1-dichloroethane, and trans-1,2-dichloroethene) previously exhibited by several other wells was also reconfirmed. The data shows some inconsistency in the levels of the contaminants detected in the resampling versus the previous samplings. Alert Laboratories reports that this level of inconsistency is to be expected since it is difficult to reproduce sampling conditions given the volatility of the compounds in question.

TRW's subcontractor, Clement Associates, has evaluated the results of the residential well sampling as part of an on-going study. They conclude that although there should be no short-term health effects from the levels of contaminants detected, a conservative course of action would be to avoid long-term consumption of this water. (It should be noted that city water service is now available and most residents are expected to accept city service because of the undesirably high iron content of the local water.) Therefore, TRW has recommended that well water use be discontinued and city water service should be accepted.

The origin of the volatile organics in the groundwater has not been determined at this time. Investigations are currently underway that should provide an indication of this source as well as additional information on the hydrogeology of the area and the extent of contamination. This information will be incorporated into the overall groundwater remediation plan currently being developed for the area around TRW Inc.'s Minerva site. We will keep you informed as this investigation proceeds.

If you have any further questions about this matter, please call me at (216)692-5475.

Respectfully,

Andrew L. Resetar

Andrew L. Resetar
Plant Engineering

ALR:aw
Enclosures

cc: Mr. G. Horn - City of Minerva
Mr. G. Gifford - Ohio EPA, Twinsburg
Mr. R. Hannahs - Ohio EPA, Columbus
Mr. R. Grimes - U.S. EPA, Chicago

SUMMARY OF RESIDENTIAL WELL ANALYSIS
RESULTS FOR THE TRW SITE IN MINERVA, OHIO

Well Number[a]	Compounds Detected	Concentrations (ppb) Detected on Date Sampled[b]			
		9/11/84	11/1/84	11/6/84	12/5/84
1	(Not Sampled)				
2	(Not Sampled)				
3		ND			
4	1,1,-Dichloroethane			1	
	Trans-1,2-dichloroethene			2	
5	(Not Sampled)				
6		ND		ND	ND
7		ND			ND
8				ND	
9		ND		ND	ND
10A	1,1-Dichloroethane			2	1
	1,1,1-Trichloroethane			2	2
10B	1,1-Dichloroethane			2	
	1,1,1-Trichloroethane			2	
11	(Not Sampled)				
12	Vinyl chloride		2		2
13A					
13B	Vinyl chloride	ND	2		2
14A					
14B	Vinyl chloride	ND		8	13
15A	Vinyl chloride	ND		9	13
15B					
16A					
16B	Vinyl chloride		11		16

(continued)

Well Number[a]	Compounds Detected	Concentrations (ppb) Detected on Date Sampled[b] 9/11/84	11/1/84	11/6/84	12/5/84
17A	Vinyl chloride	ND	2		9
17B	Vinyl chloride		2		
18		ND			
19A	Trans-1,2-dichloroethene	1	ND		ND
	Vinyl chloride	ND	2		3
19B					
20	Vinyl chloride		7		15
21	Trans-1,2-dichloroethene	2	1		ND[c]
	1,1-Dichloroethane	1	1		ND[c]
	Vinyl chloride	ND	8		ND[c]
22	(Not sampled)				
23	1,1-Dichloroethane	3	2		
	Trans-1,2-dichloroethene	3	2		
	Vinyl chloride	ND	12		
24	(Not sampled)				
25	(Not sampled)				
26		ND	ND		
27					ND

[a] In cases where a single well serves two or more residences, this is denoted by using a common well number with an "A" or "B". In some cases "duplicate" samples were obtained from the same well through each residence. Agreement in results from such duplicate analyses are excellent.

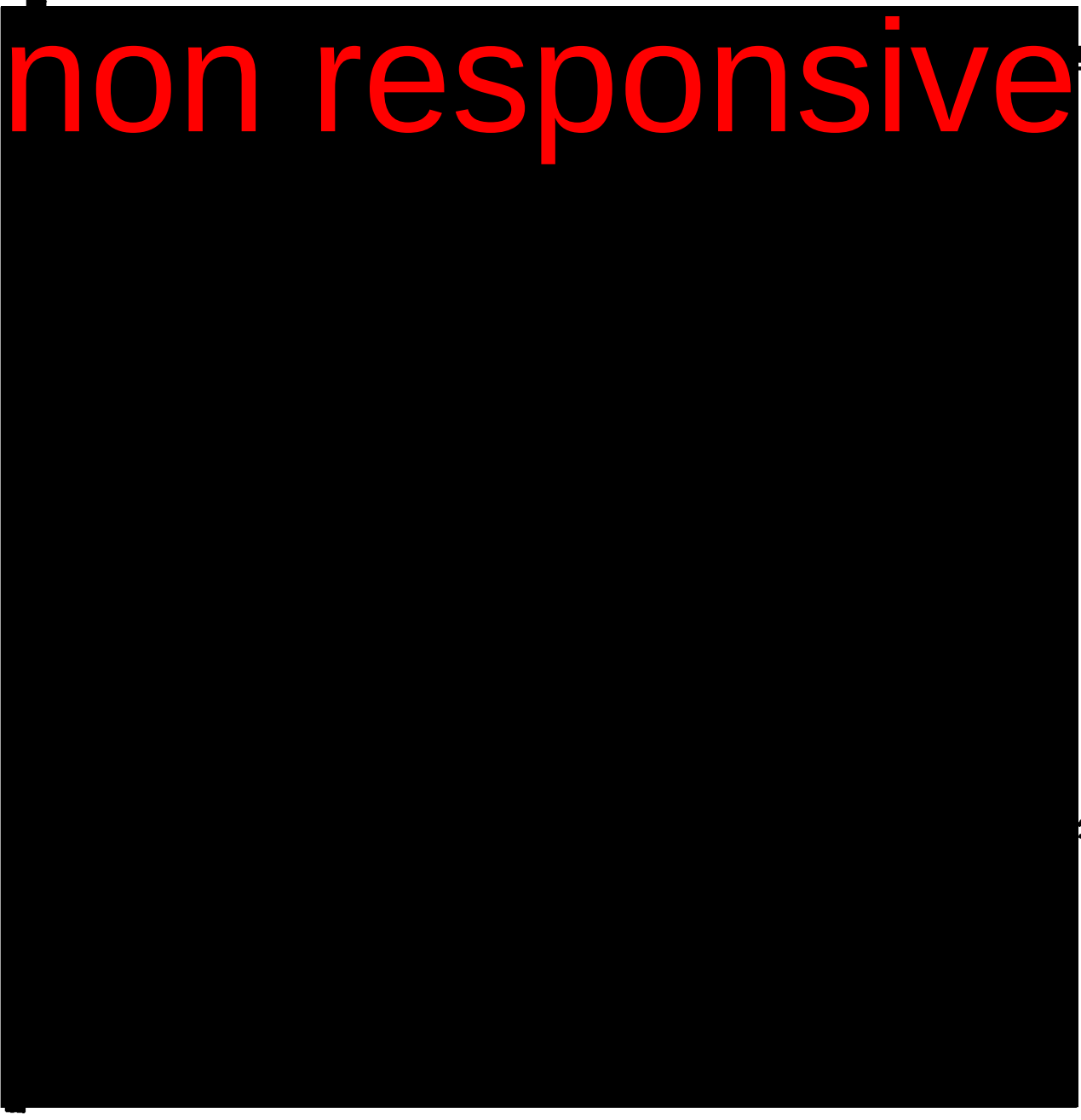
[b] "ND" means not detected. Otherwise only positive results are presented (i.e., volatile organics not detected in any of the analyses from a specific well are not listed).

[c] The sample from well 21 is now city water.

KEY

SAMPLING SUMMARY
"OLD PARK" RESIDENTIAL WELLS
NORTH OF THE BIG SANDY CREEK

Reference Dwg.
SK-100
10/26/84 Rev. 1



T SAMPLE	2ND SAMPLE
-	-
-	-
9/11/84	-
11/6/84	-
	-
-	-
9/11/84	11/6/84
9/11/84	-
11/6/84	-
9/11/84	11/6/84
11/6/84	-
11/6/84	-
-	
11/1/84	-
9/11/84	11/1/84
9/11/84	11/6/84
9/11/84	11/6/84
11/1/84	-
9/11/84	11/1/84
9/11/84	-
9/11/84	11/1/84
11/1/84	-
9/11/84	11/1/84
-	-
9/11/84	11/1/84
-	-
-	-
9/11/84	11/6/84

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APPENDIX 6

Priority Pollutant Laboratory Report

WADSWORTH
TESTING
LABORATORIES,
INC.

P.O. Box 208, 1600 Fourth Street, S.E., Canton, Ohio 44701 (216) 454-5809

ANALYTICAL REPORT

TRW

MINERVA, OHIO

PRESENTED TO:

CLEMENT ASSOCIATES
D. WAYNE BERMAN, PH.D.

WADSWORTH TESTING LABORATORIES, INC.

Marvin W. Stephens

Marvin W. Stephens, Ph.D.
Vice President & Technical Director

October 24, 1984

METALLIC COMPOUNDS ANALYTICAL REPORT

Company: TRW
Sample Identification: TW-1 10/4/84
Laboratory Identification: 80552
Sample Matrix: Water

Cyanide	<0.005	mg/L
Phenol	<0.005	mg/L
Antimony	<0.1	mg/L
Arsenic	<0.005	mg/L
Beryllium	<0.01	mg/L
Cadmium	<0.01	mg/L
Chromium	<0.02	mg/L
Hexavalent Chromium	<0.02	mg/L
Copper	<0.01	mg/L
Lead	<0.05	mg/L
Mercury	<0.005	mg/L
Nickel	<0.05	mg/L
Selenium	<0.005	mg/L
Silver	<0.01	mg/L
Thallium	<0.05	mg/L
Zinc	0.03	mg/L

VOLATILE COMPOUNDS ANALYTICAL REPORT

Company: TRW
Sample Identification: TW-1, 10/4/84
Laboratory Identification: 80552
Sample Matrix: Water

Benzene	ND	trans-1,2-Dichloroethene	ND
Bromodichloromethane	ND	1,2-Dichloropropane	ND
Bromoform	ND	cis-1,3-Dichloropropene	ND
Bromomethane	ND	trans-1,3-Dichloropropene	ND
Carbon tetrachloride	ND	Ethylbenzene	ND
Chlorobenzene	ND	Methylene chloride	ND
Chloroethane	ND	1,1,2,2-Tetrachloroethane	ND
2-Chloroethylvinyl ether	ND	Tetrachloroethene	ND
Chloroform	ND	Toluene	ND
Chloromethane	ND	1,1,1-Trichloroethane	ND
Dibromochloromethane	ND	1,1,2-Trichloroethane	ND
1,1-Dichloroethane	ND	Trichloroethene	ND
1,2-Dichloroethane	ND	Trichlorofluoromethane	ND
1,1-Dichloroethene	ND	Vinyl chloride	ND

Note: ND (None detected, lower detectable limit 10 ug/L)

BASE/NEUTRAL COMPOUNDS ANALYTICAL REPORT

Company: TRW
Sample Identification: TW-1, 10/4/84
Laboratory Identification: 80552
Sample Matrix: Water

Acenaphthene	ND	Diethyl phthalate	ND
Acenaphthylene	ND	Dimethyl phthalate	ND
Anthracene	ND	2,4-Dinitrotoluene	ND
Benzidine	ND*	2,6-Dinitrotoluene	ND
Benzo(a)anthracene	ND*	Di-n-octyl phthalate	ND*
Benzo(b)fluoranthene	ND*	1,2-Diphenylhydrazine	ND*
Benzo(k)fluoranthene	ND*	Fluoranthene	ND
Benzo(ghi)perylene	ND*	Fluorene	ND
Benzo(a)pyrene	ND*	Hexachlorobenzene	ND
Bis(2-chloroethoxy)methane	ND	Hexachlorobutadiene	ND
Bis(2-chloroethyl)ether	ND*	Hexachlorocyclopentadiene	ND*
Bis(2-chloroisopropyl)ether	ND*	Hexachloroethane	ND
Bis(2-ethylhexyl)phthalate	90 ug/L	Indeno(1,2,3-cd)pyrene	ND*
4-Bromophenyl phenyl ether	ND	Isophorone	ND
Butyl benzyl phthalate	ND*	Naphthalene	ND
2-Chloronaphthalene	ND	Nitrobenzene	ND
4-Chlorophenyl phenyl ether	ND	N-Nitrosodimethylamine	ND
Chrysene	ND*	N-Nitrosodiphenylamine	ND
Dibenzo(a,h)anthracene	ND*	N-Nitrosodi-n-propylamine	ND
Di-n-butyl phthalate	ND	Phenanthrene	ND
1,2-Dichlorobenzene	ND	Pyrene	ND
1,3-Dichlorobenzene	ND	1,2,4,Trichlorobenzene	ND
1,4-Dichlorobenzene	ND		
3,3'-Dichlorobenzidine	ND*		

Note: ND (None detected, lower detectable limit = 10 ug/L)
ND* (None detected, lower detectable limit = 100 ug/L)

ACID COMPOUNDS ANALYTICAL REPORT

Company: TRW
Sample Identification: TW-1, 10/4/84
Laboratory Identification: 80552
Sample Matrix: Water

4-Chloro-3-methylphenol	ND	4-Nitrophenol	ND*
2-Chlorophenol	ND	Pentachlorophenol	ND*
2,4-Dichlorphenol	ND	Phenol	ND
2,4-Dimethylphenol	ND	2,4,6-Trichlorophenol	ND
2,4-Dinitrophenol	ND*		
2-Methyl-4,6-dinitrophenol	ND*		
2-Nitrophenol	ND		

ND (None detected, lower detectable limit = 10 ug/L)

ND* (None detected, lower detectable limit= 50 ug/L)

METALLIC COMPOUNDS ANALYTICAL REPORT

Company: TRW
Sample Identification: TW-10 10/4/84
Laboratory Identification: 80553
Sample Matrix: Water

Cyanide	0.040	mg/L
Phenol	<0.005	mg/L
Antimony	<0.1	mg/L
Arsenic	0.05	mg/L
Beryllium	<0.01	mg/L
Cadmium	<0.01	mg/L
Chromium	<0.02	mg/L
Hexavalent Chromium	<0.02	mg/L
Copper	0.02	mg/L
Lead	<0.05	mg/L
Mercury	<0.005	mg/L
Nickel	<0.05	mg/L
Selenium	<0.005	mg/L
Silver	<0.01	mg/L
Thallium	<0.05	mg/L
Zinc	0.02	mg/L

VOLATILE COMPOUNDS ANALYTICAL REPORT

Company: TRW
Sample Identification: TW-10, 10/4/84
Laboratory Identification: 80553
Sample Matrix: Water

Benzene	ND	trans-1,2-Dichloroethene	530 ug/L
Bromodichloromethane	ND	1,2-Dichloropropane	ND
Bromoform	ND	cis-1,3-Dichloropropene	ND
Bromomethane	ND	trans-1,3-Dichloropropene	ND
Carbon tetrachloride	ND	Ethylbenzene	ND
Chlorobenzene	ND	Methylene chloride	ND
Chloroethane	ND	1,1,2,2-Tetrachloroethane	ND
2-Chloroethylvinyl ether	ND	Tetrachloroethene	ND
Chloroform	ND	Toluene	ND
Chloromethane	ND	1,1,1-Trichloroethane	ND
Dibromochloromethane	ND	1,1,2-Trichloroethane	ND
1,1-Dichloroethane	280 ug/L	Trichloroethene	250 ug/L
1,2-Dichloroethane	ND	Trichlorofluoromethane	ND
1,1-Dichloroethene	ND	Vinyl chloride	52 ug/L

Note: ND (None detected, lower detectable limit 20 ug/L)

BASE/NEUTRAL COMPOUNDS ANALYTICAL REPORT

Company: TRW
Sample Identification: TW-10, 10/4/84
Laboratory Identification: 80553
Sample Matrix: Water

Acenaphthene	ND	Diethyl phthalate	ND
Acenaphthylene	ND	Dimethyl phthalate	ND
Anthracene	ND	2,4-Dinitrotoluene	ND
Benzidine	ND*	2,6-Dinitrotoluene	ND
Benzo(a)anthracene	ND*	Di-n-octyl phthalate	ND*
Benzo(b)fluoranthene	ND*	1,2-Diphenylhydrazine	ND*
Benzo(k)fluoranthene	ND*	Fluoranthene	ND
Benzo(ghi)perylene	ND*	Fluorene	ND
Benzo(a)pyrene	ND*	Hexachlorobenzene	ND
Bis(2-chloroethoxy)methane	ND	Hexachlorobutadiene	ND
Bis(2-chloroethyl)ether	ND*	Hexachlorocyclopentadiene	ND*
Bis(2-chloroisopropyl)ether	ND*	Hexachloroethane	ND
Bis(2-ethylhexyl)phthalate	ND*	Indeno(1,2,3-cd)pyrene	ND*
4-Bromophenyl phenyl ether	ND	Isophorone	ND
Butyl benzyl phthalate	ND*	Naphthalene	ND
2-Chloronaphthalene	ND	Nitrobenzene	ND
4-Chlorophenyl phenyl ether	ND	N-Nitrosodimethylamine	ND
Chrysene	ND*	N-Nitrosodiphenylamine	ND
Dibenzo(a,h)anthracene	ND*	N-Nitrosodi-n-propylamine	ND
Di-n-butyl phthalate	ND	Phenanthrene	ND
1,2-Dichlorobenzene	ND	Pyrene	ND
1,3-Dichlorobenzene	ND	1,2,4,Trichlorobenzene	ND
1,4-Dichlorobenzene	ND		
3,3'-Dichlorobenzidine	ND*		

Note: ND (None detected, lower detectable limit = 10 ug/L)
ND* (None detected, lower detectable limit = 100 ug/L)

ACID COMPOUNDS ANALYTICAL REPORT

Company: TRW
Sample Identification: TW-10, 10/4/84
Laboratory Identification: 80553
Sample Matrix: Water

4-Chloro-3-methylphenol	ND	4-Nitrophenol	ND*
2-Chlorophenol	ND	Pentachlorophenol	ND*
2,4-Dichlorphenol	ND	Phenol	ND
2,4-Dimethylphenol	ND	2,4,6-Trichlorophenol	ND
2,4-Dinitrophenol	ND*		
2-Methyl-4,6-dinitrophenol	ND*		
2-Nitrophenol	ND		

ND (None detected, lower detectable limit = 10 ug/L)

ND* (None detected, lower detectable limit= 50 ug/L)

METALLIC COMPOUNDS ANALYTICAL REPORT

Company: TRW
Sample Identification: TW-13 10/4/84
Laboratory Identification: 80554
Sample Matrix: Water

Cyanide	<0.005	mg/L
Phenol	<0.005	mg/L
Antimony	<0.1	mg/L
Arsenic	<0.005	mg/L
Beryllium	<0.01	mg/L
Cadmium	<0.01	mg/L
Chromium	<0.02	mg/L
Hexavalent Chromium	<0.02	mg/L
Copper	<0.01	mg/L
Lead	<0.05	mg/L
Mercury	<0.005	mg/L
Nickel	<0.05	mg/L
Selenium	<0.005	mg/L
Silver	<0.01	mg/L
Thallium	<0.05	mg/L
Zinc	0.01	mg/L

VOLATILE COMPOUNDS ANALYTICAL REPORT

Company: TRW
Sample Identification: TW-13, 10/4/84
Laboratory Identification: 80554
Sample Matrix: Water

Benzene	ND	trans-1,2-Dichloroethene	490 ug/L
Bromodichloromethane	ND	1,2-Dichloropropane	ND
Bromoform	ND	cis-1,3-Dichloropropene	ND
Bromomethane	ND	trans-1,3-Dichloropropene	ND
Carbon tetrachloride	ND	Ethylbenzene	ND
Chlorobenzene	ND	Methylene chloride	ND
Chloroethane	ND	1,1,2,2-Tetrachloroethane	ND
2-Chloroethylvinyl ether	ND	Tetrachloroethene	ND
Chloroform	ND	Toluene	ND
Chloromethane	ND	1,1,1-Trichloroethane	BMDL
Dibromochloromethane	ND	1,1,2-Trichloroethane	ND
1,1-Dichloroethane	1,600 ug/L	Trichloroethene	BMDL
1,2-Dichloroethane	BMDL	Trichlorofluoromethane	ND
1,1-Dichloroethene	ND	Vinyl chloride	150 ug/L

Note: ND (None detected, lower detectable limit 50 ug/L)
BMDL (Below minimum detectable limit)

BASE/NEUTRAL COMPOUNDS ANALYTICAL REPORT

Company: TRW
Sample Identification: TW-13, 10/4/84
Laboratory Identification: 80554
Sample Matrix: Water

Acenaphthene	ND	Diethyl phthalate	ND
Acenaphthylene	ND	Dimethyl phthalate	ND
Anthracene	ND	2,4-Dinitrotoluene	ND
Benzidine	ND*	2,6-Dinitrotoluene	ND
Benzo(a)anthracene	ND*	Di-n-octyl phthalate	ND*
Benzo(b)fluoranthene	ND*	1,2-Diphenylhydrazine	ND*
Benzo(k)fluoranthene	ND*	Fluoranthene	ND
Benzo(ghi)perylene	ND*	Fluorene	ND
Benzo(a)pyrene	ND*	Hexachlorobenzene	ND
Bis(2-chloroethoxy)methane	ND	Hexachlorobutadiene	ND
Bis(2-chloroethyl)ether	ND*	Hexachlorocyclopentadiene	ND*
Bis(2-chloroisopropyl)ether	ND*	Hexachloroethane	ND
Bis(2-ethylhexyl)phthalate	ND*	Indeno(1,2,3-cd)pyrene	ND*
4-Bromophenyl phenyl ether	ND	Isophorone	ND
Butyl benzyl phthalate	ND*	Naphthalene	ND
2-Chloronaphthalene	ND	Nitrobenzene	ND
4-Chlorophenyl phenyl ether	ND	N-Nitrosodimethylamine	ND
Chrysene	ND*	N-Nitrosodiphenylamine	ND
Dibenzo(a,h)anthracene	ND*	N-Nitrosodi-n-propylamine	ND
Di-n-butyl phthalate	ND	Phenanthrene	ND
1,2-Dichlorobenzene	ND	Pyrene	ND
1,3-Dichlorobenzene	ND	1,2,4,Trichlorobenzene	ND
1,4-Dichlorobenzene	ND		
3,3'-Dichlorobenzidine	ND*		

Note: ND (None detected, lower detectable limit = 10 ug/L)
ND* (None detected, lower detectable limit = 100 ug/L)

ACID COMPOUNDS ANALYTICAL REPORT

Company: TRW
Sample Identification: TW-13, 10/4/84
Laboratory Identification: 80554
Sample Matrix: Water

4-Chloro-3-methylphenol	ND	4-Nitrophenol	ND*
2-Chlorophenol	ND	Pentachlorophenol	ND*
2,4-Dichlorphenol	ND	Phenol	ND
2,4-Dimethylphenol	ND	2,4,6-Trichlorophenol	ND
2,4-Dinitrophenol	ND*		
2-Methyl-4,6-dinitrophenol	ND*		
2-Nitrophenol	ND		

ND (None detected, lower detectable limit = 10 ug/L)

ND* (None detected, lower detectable limit= 50 ug/L)

METALLIC COMPOUNDS ANALYTICAL REPORT

Company: TRW
Sample Identification: TW-19 10/4/84
Laboratory Identification: 80555
Sample Matrix: Water

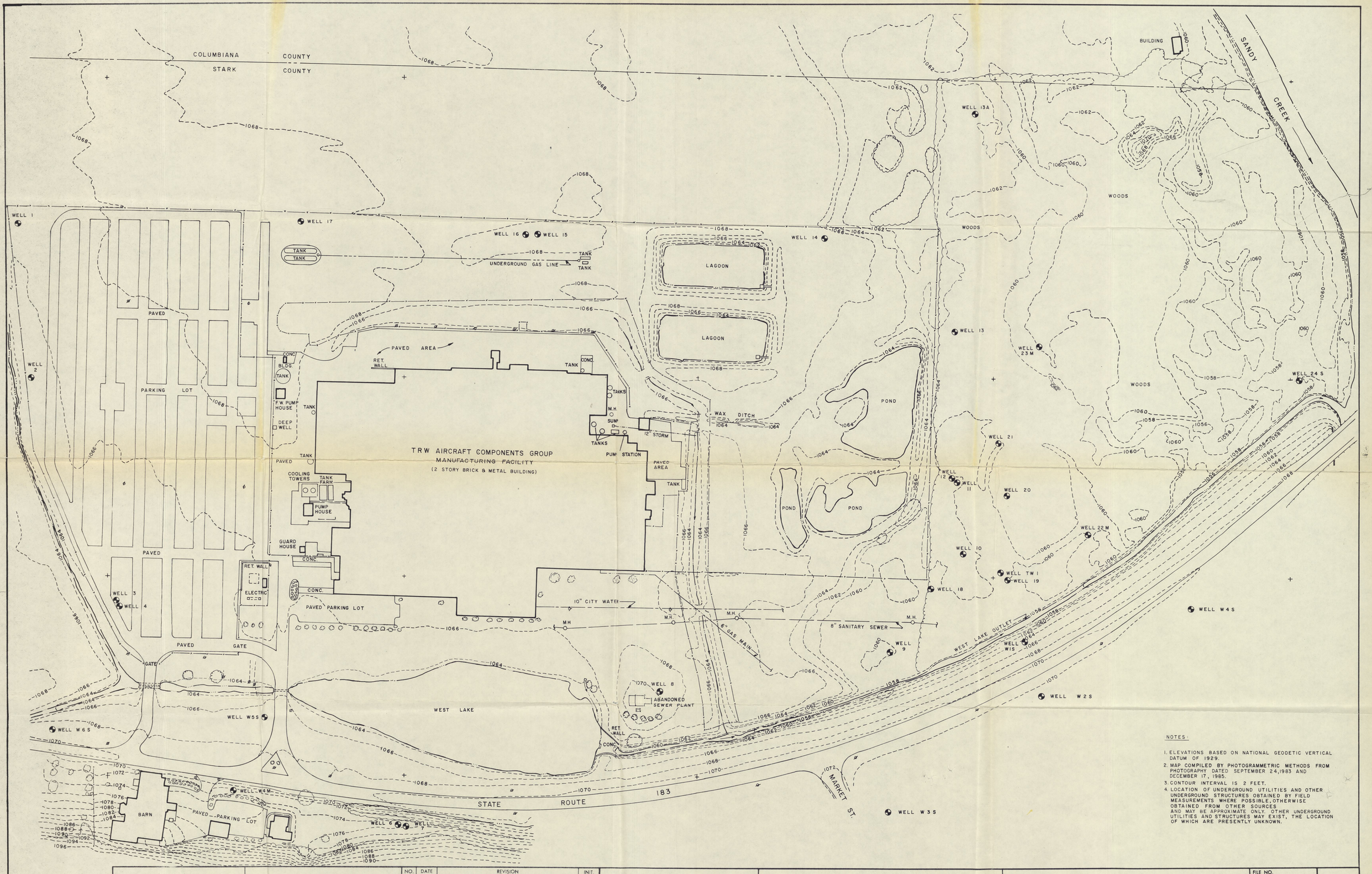
Cyanide	0.053	mg/L
Phenol	0.01	mg/L
Antimony	<0.1	mg/L
Arsenic	<0.005	mg/L
Beryllium	<0.01	mg/L
Cadmium	<0.01	mg/L
Chromium	<0.02	mg/L
Hexavalent Chromium	<0.02	mg/L
Copper	0.87	mg/L
Lead	0.08	mg/L
Mercury	<0.005	mg/L
Nickel	<0.05	mg/L
Selenium	<0.005	mg/L
Silver	<0.01	mg/L
Thallium	<0.05	mg/L
Zinc	0.03	mg/L

VOLATILE COMPOUNDS ANALYTICAL REPORT

Company: TRW
Sample Identification: TW-19 10/4/84
Laboratory Identification: 80555
Sample Matrix: Water

Benzene	ND	trans-1,2-Dichloroethene	740 ug/L
Bromodichloromethane	ND	1,2-Dichloropropane	ND
Bromoform	ND	cis-1,3-Dichloropropene	ND
Bromomethane	ND	trans-1,3-Dichloropropene	ND
Carbon tetrachloride	ND	Ethylbenzene	ND
Chlorobenzene	ND	Methylene chloride	ND
Chloroethane	ND	1,1,2,2-Tetrachloroethane	ND
2-Chloroethylvinyl ether	ND	Tetrachloroethene	ND
Chloroform	ND	Toluene	ND
Chloromethane	ND	1,1,1-Trichloroethane	ND
Dibromochloromethane	ND	1,1,2-Trichloroethane	ND
1,1-Dichloroethane	880 ug/L	Trichloroethene	950 ug/L
1,2-Dichloroethane	ND	Trichlorofluoromethane	ND
1,1-Dichloroethene	ND	Vinyl chloride	190 ug/L

Note: ND (None detected, lower detectable limit 100 ug/L)



NOTES:

1. ELEVATIONS BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.
2. MAP COMPILED BY PHOTOGRAMMETRIC METHODS FROM PHOTOGRAPHY DATED SEPTEMBER 24,1983 AND DECEMBER 17, 1985.
3. CONTOUR INTERVAL IS 2 FEET.
4. LOCATION OF UNDERGROUND UTILITIES AND OTHER UNDERGROUND STRUCTURES OBTAINED BY FIELD MEASUREMENTS WHERE POSSIBLE, OTHERWISE OBTAINED FROM OTHER SOURCES AND MAY BE APPROXIMATE ONLY. OTHER UNDERGROUND UTILITIES AND STRUCTURES MAY EXIST, THE LOCATION OF WHICH ARE PRESENTLY UNKNOWN.

In charge of _____
Designed by _____ Checked by _____
Made by _____

80 0 80 160

NO.	DATE	REVISION	INIT.

O'BRIEN & GERE ENGINEERS, INC.
Syracuse, New York

TRW - MINERVA PROJECT

TOPOGRAPHIC MAP

FILE NO. 2795.005-

DATE APRIL 1985

BASE/NEUTRAL COMPOUNDS ANALYTICAL REPORT

Company: TRW
Sample Identification: TW-19, 10/4/84
Laboratory Identification: 80555
Sample Matrix: Water

Acenaphthene	ND	Diethyl phthalate	ND
Acenaphthylene	ND	Dimethyl phthalate	ND
Anthracene	ND	2,4-Dinitrotoluene	ND
Benzidine	ND*	2,6-Dinitrotoluene	ND
Benzo(a)anthracene	ND*	Di-n-octyl phthalate	ND*
Benzo(b)fluoranthene	ND*	1,2-Diphenylhydrazine	ND*
Benzo(k)fluoranthene	ND*	Fluoranthene	ND
Benzo(ghi)perylene	ND*	Fluorene	ND
Benzo(a)pyrene	ND*	Hexachlorobenzene	ND
Bis(2-chloroethoxy)methane	ND	Hexachlorobutadiene	ND
Bis(2-chloroethyl)ether	ND*	Hexachlorocyclopentadiene	ND*
Bis(2-chloroisopropyl)ether	ND*	Hexachloroethane	ND
Bis(2-ethylhexyl)phthalate	ND*	Indeno(1,2,3-cd)pyrene	ND*
4-Bromophenyl phenyl ether	ND	Isophorone	ND
Butyl benzyl phthalate	ND*	Naphthalene	ND
2-Chloronaphthalene	ND	Nitrobenzene	ND
4-Chlorophenyl phenyl ether	ND	N-Nitrosodimethylamine	ND
Chrysene	ND*	N-Nitrosodiphenylamine	ND
Dibenzo(a,h)anthracene	ND*	N-Nitrosodi-n-propylamine	ND
Di-n-butyl phthalate	ND	Phenanthrene	ND
1,2-Dichlorobenzene	ND	Pyrene	ND
1,3-Dichlorobenzene	ND	1,2,4,Trichlorobenzene	ND
1,4-Dichlorobenzene	ND		
3,3'-Dichlorobenzidine	ND*		

Note: ND (None detected, lower detectable limit = 10 ug/L)
ND* (None detected, lower detectable limit = 100 ug/L)

ACID COMPOUNDS ANALYTICAL REPORT

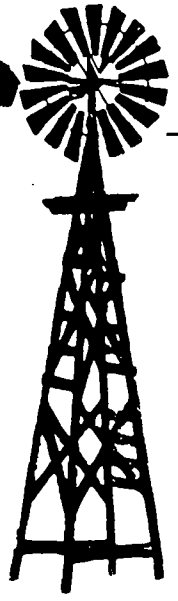
Company: TRW
Sample Identification: TW-19, 10/4/84
Laboratory Identification: 80555
Sample Matrix: Water

4-Chloro-3-methylphenol	ND	4-Nitrophenol	ND*
2-Chlorophenol	ND	Pentachlorophenol	ND*
2,4-Dichlorphenol	ND	Phenol	ND
2,4-Dimethylphenol	ND	2,4,6-Trichlorophenol	ND
2,4-Dinitrophenol	ND*		
2-Methyl-4,6-dinitrophenol	ND*		
2-Nitrophenol	ND		

ND (None detected, lower detectable limit = 10 ug/L)
ND* (None detected, lower detectable limit= 50 ug/L)

APPENDIX 7

Boring Logs



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HOLE#1

0 - 3	topsoil
3 - 6	clay
6 - 9	sand and gravel - large round
9 - 12	sand and gravel - medium
12 - 15	sand and gravel - small

STATIC - 4' 10"
WATER ENCOUNTERED AT - 6'
TOTAL DEPTH BELOW GROUND LEVEL - 10'4"
TOTAL DEPTH OF 3" PIPE BELOW GROUND - 5' 4"

HOLE#2

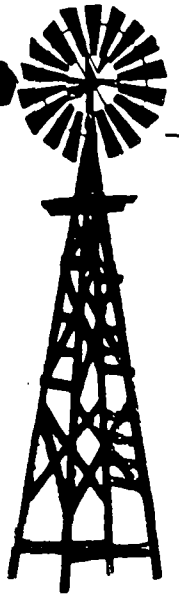
0 - 2	topsoil (sandy)
2 - 3	clay
3 - 8	sand and gravel - medium angular
8 - 11	sand and gravel - small round

STATIC - 4' 2"
WATER FIRST ENCOUNTERED AT - 5'
TOTAL DEPTH - 9' 2"
DEPTH OF 3" PIPE - 4' 2"

HOLE#3

0 - 2	driveway material
2 - 4	brown sand
4 - 9	brown sand and gravel - round small

STATIC - 3' 1"
TOTAL DEPTH - 8' 9"
DEPTH OF PIPE - 3' 9"
WATER ENCOUNTERED - 3'



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HOLE#~~4~~ 3

0 - 2	driveway material
2 - 4	brown sand
4 - 14	brown sand and gravel

STATIC - 3'
TOTAL DEPTH - 13' 8"
PIPE DEPTH - 8' 8"
WATER ENCOUNTERED - 3'

HOLE#5

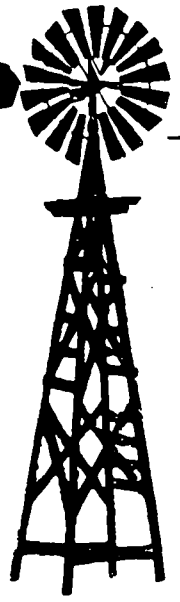
0 - 3	soil
3 - 12	brown clay
12 - 15	brown sandy clay
15 - 30	gray clay
30 - 33	soft shale
33 - 36	blue shale

STATIC - 26
TOTAL DEPTH - 36'
PIPE DEPTH - 31'
WATER ENCOUNTED - 30

HOLE#6

0 - 5	soil
5 - 12	clay
12 - 15	heavy gravel and sand
15 - 18	light gravel and sand
18 - 21	sand
21 - 24	sand and clay
24 - 27	clay and sand
27 - 30	clay and gravel - small angular
30 - 33	clay and gravel - medium
33 - 36	shale
36 - 38	shale

STATIC - 22
TOTAL DEPTH - 38'
PIPE DEPTH - 33'
WATER ENCOUNTED - 22



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HOLE#16

0 - 3	soil
3 - 6	soil and clay
6 - 12	sand and gravel - medium
12 - 18	sand
18 - 21	sand and gravel - small

STATIC -
TOTAL DEPTH -
DEPTH OF PIPE -
WATER AT -

HOLE#17

0 - 3	soil
3 - 6	clay and soil
6 - 12	sand and gravel - medium angular
12 - 15	sand and gravel - medium round
15 - 18	small sand and gravel
18 - 21	sand

STATIC -
TOTAL DEPTH -
DEPTH OF PIPE -
WATER AT -

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HOLE#13a

0 - 3 light gray clay
3 - 6 brown sand and gravel - large

STATIC - 2
TOTAL DEPTH - 7'
DEPTH OF PIPE - 2'
WATER AT - 3'

HOLE#14

0 - 3 gray clay - like soil
3 - 6 sand and gravel - medium
6 - 9 sand gravel - large
9 - 12 sand and gravel - small
12 - 15 sand

STATIC - 7'0"
TOTAL DEPTH - 15'
DEPTH OF PIPE - 10'
WATER OF - 8'

HOLE#15

0 - 3 sandy soil
3 - 6 sand and medium gravel
6 - 9 blackish mud and gravel
9 - 15 sand and small gravel
15 - 18 sand

static -
Total Depth -
Depth of Pipe -
Water at -

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HOLE#10

0 - 3 sand and gravel
3 - 6 sand and gravel - large

STATIC - 2' 1"
TOTAL DEPTH - 7'
DEPTH OF PIPE - 2'
WATER AT - 2'

HOLE#11

0 - 3 small sand and gravel
3 - 6 sand
6 - 12 sand and small gravel

STATIC - 3'
TOTAL DEPTH - 12'
DEPTH OF PIPE - 7'
WATER AT - 3'

HOLE #12

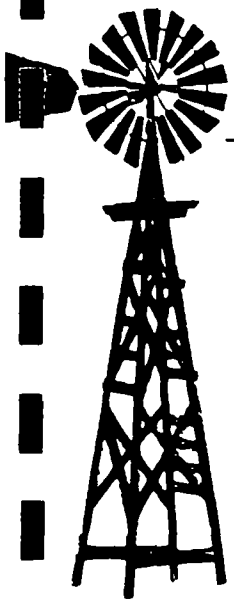
0 - 2 soil
2 - 3 yellow clay
3 - 5 gray clay and sand
5 - 7 black sand and gravel

STATIC - 2' 10"
TOTAL DEPTH - 7'
DEPTH OF PIPE - 2'
WATER AT - 3'

HOLE#13

0 - 3 gray clay and gravel
3 - 6 brown sand and gravel

STATIC - 2' 11"
TOTAL DEPTH - 7'
DEPTH OF PIPE - 2'
WATER AT - 3'



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Louisville, Ohio 44641
Phone (216) 875-8457

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HOLE#7

0 - 3	soil
3 - 6	clay
6 - 9	sand and clay
9 - 12	sand and clay
12 - 15	sand and gravel and clay
15 - 18	gravel and clay
18 - 21	clay
21 - 24	hard clay
24 - 27	shale
27 - 30	gray shale
30 - 33	shale and sand

STATIC -
TOTAL DEPTH - 33'
DEPTH OF PIPE - 28'
WATER AT - 26'

HOLE #8

0 - 5	soil
5 - 7	soil and gravel
7 - 18	sand and gravel - round
18 - 21	sand

STATIC - 10' 5"
TOTAL DEPTH - 15'
DEPTH OF PIPE 10'
WATER AT - 11'

HOLE#9

0 - 3	brown sand
3 - 4	clay
4 - 7	sand and small gravel

STATIC - 1' 11"
TOTAL DEPTH - 7'
DEPTH OF PIPE - 2'
WATER AT- 2'

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AKRON, OHIO 44313
(216) 929-4100

DRILLING LOG

Client CLEMENT & ASSOCIATES
Project TRW - Monitor Wells No.
Location Minerva, Ohio Hole No. 18 Elev.
Date: Started 11/2/82 Completed 11/3/82 Driller GM, DJ
Sampler: Dia 4 ins. Type Bailer Hammer Wt. lbs. Fall ins.
Casing: Dia 7 ins. Type T & C Hammer Wt. lbs. Fall ins.
Water/Mud used in drilling X Yes No; Water depth during drilling 8.0 Ft.
Water Depth: Upon Compl. 3.5 SWL Ft.; 2 Hrs. after Compl. 1.5 Ft.

Depth (Ft.)	Material Description	Sample No	Sample Depth	Blows/6"	N	Rec (Ins.)
3.5'	Brown clay, silt, and rock fragments, moist	1	3.0	1 qt.		
6.5'	Brown silt and clay, some gravel, moist	2	6.0'	1 qt.		
8.0'	Brown silt with clay and gravel, moist					
9.0'	Brown gravel and sand, wet	3	9.0'	1 qt.		
	TERMINATION DEPTH: 9.0'					
	Monitor Well set					

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DRILLING LOG

Client CLEMENT & ASSOCIATES
Project TRW Monitor Well No.
Location Minerva, Ohio Hole No. #19 Elev.
Date: Started 11/3/82 Completed 11/4/82 Driller G.M., D.C.
Sampler: Dia 4 ins. Type Bailer Hammer Wt. lbs. Fall ins.
Casing: Dia 7 ins. Type T + C Hammer Wt. lbs. Fall ins.
Water/Mud used in drilling x Yes No; Water depth during drilling 5', 9' Ft.
Water Depth: Upon Compl. SWL Ft.; 2 Hrs. after Compl. Ft.

Depth (Ft.)	Material Description	Sample No	Sample Depth	Blows/6"	N	Rec (Ins.)
	Topsoil (removed by backhoe)				12:45 PM	
1.0'	Brown clayey sand	1	3.0	1 qt. sample	11/3/82	
5.0'	Coal fragments	2	6.0'	1 qt. sample	11:00 AM 11/4/82	
9.0'	Gray sand and gravel, wet	3	9.0'	1 qt. sample	12:00 PM 11/4/82	
10.0'	TERMINATION DEPTH: 10.0'					
	Monitor Well set					

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DRILLING LOG

Client CLEMENT & ASSOCIATES
Project TRW - Monitor Wells No.
Location Minerva, Ohio Hole No. B-20 Elev.
Date: Started 11/8/82 Completed 11/9/82 Driller G.M., D.C., R.B.
Sampler: Dia 4 ins. Type Bailer Hammer Wt. lbs. Fall ins.
Casing: Dia 7 ins. Type T + C Hammer Wt. lbs. Fall ins.
Water/Mud used in drilling x Yes No; Water depth during drilling 4', 6', 9' Ft.
Water Depth: Upon Compl. SWL 5.5 Ft.; 2 Hrs. after Compl. 5.5 Ft.

Depth (Ft.)	Material Description	Sample No	Sample Depth	Blows/6"	N	Rec (Ins.)
4.0'	Brown silty sand, moist	1	3.0	1 qt. sample	1:30 PM	
6.0'	Brown gravel, sand and silt, moist	2	6.0'	1 qt. sample	2:30 PM	
9.0'	Brown and gray gravel, some sand and silt, wet	3	9.0'	1 qt. sample	3:00 PM	
9.5'	Brown and gray gravel, wet					
	TERMINATION DEPTH: 9.5'					
	Monitor Well set					

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DRILLING LOG

Client CLEMENT & ASSOCIATES
Project TRW - Monitor Wells No.
Location Minerva, Ohio Hole No. B-21 Elev.
Date: Started 11/10/82 Completed 11/10/82 Driller GM, DJ
Sampler: Dia 4 ins. Type Bailer Hammer Wt. lbs. Fall ins.
Casing: Dia 7 ins. Type T + C Hammer Wt. lbs. Fall ins.
Water/Mud used in drilling X Yes No; Water depth during drilling Ft.
Water Depth: Upon Compl. SWL 5.5 Ft.; 2 Hrs. after Compl. 5.5 Ft.

Depth (Ft.)	Material Description	Sample No	Sample Depth	Blows/6"	N	Rec (Ins.)
4.5'	Brown silty sand, some clay, moist	1	3.0	1 qt. sample	10:00 AM	
7.0'	Brown silt and sand	2	6.0	1 qt. sample	10:45 AM	
8.5'	Brown and gray silt with gravel and sand, moist	3	9.0	1 qt. sample	12:30 PM	
9.5'	Brown sand, trace of gravel, wet					
	TERMINATION DEPTH: 9.5'					
	Monitor Well installed					

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MASSILLON, OHIO

DRILLED FOR TRW Aircraft Components Group - Minerva, Ohio HOLE NO. W 1 S

DRILLED BY Alan Graber DRILLER COMPLETED Jan. 15, 19 85

LOCATION Approximately 480 feet south of center line of connector road & 55 feet east of state route 183 center line

THICKNESS OF STRATA	STRATA	TOTAL DEPTH	HEAVED	WATER FROM SURFACE
7 ft.	Brown Clay, Sand & Stones	7 ft.		
7 ft.	Brown Sandy Clay	14 ft.		
6 ft.	Brown Sand & Clay	20 ft.		
7 ft.	Brown Sand, Smaller Gravel & Clay	27 ft.		
15 ft.	Gray Sand, Some Gravel & Clay	42 ft.		
	Test hole converted to a 2" water sample hole, screened 14 - 34 feet.			
	Static water level - 9' 6"			

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MASSILLON, OHIO

DRILLED FOR TRW Aircraft Components Group - Minerva, Ohio HOLE NO. W2S

DRILLED BY Alan Graber DRILLER COMPLETED Jan. 7, 19 85

LOCATION Approximately 135 ft. east of S.R. 183, 35 ft. south of Connector Rd.

THICKNESS OF STRATA	STRATA	TOTAL DEPTH	HEAVED	WATER FROM SURFACE
13 ft.	Brown Clay, Sand & Stones	13 ft.		
7 ft.	Gray Sandy Clay & Few Stones	20 ft.		
7 ft.	Brown Sand, Gravel & Clay (dirty)	27 ft.		
14 ft.	Gray Sand, Smaller Gravel & Clay	41 ft.		
3 ft.	Gray Sandy Clay	44 ft.		
	Test hole converted to a 2" water sample hole, screened 20 to 40 feet.			
	Static water level - 9' 6"			

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MASSILLON, OHIO

DRILLED FOR TRW Aircraft Components Group - Minerva, Ohio HOLE NO. W 3 S

DRILLED BY Alan Graber DRILLER COMPLETED Jan. 17, 19 85

LOCATION Approximately 460 feet south of center line of connector road & 53 feet west of state route 183 center line

THICKNESS OF STRATA	STRATA	TOTAL DEPTH	HEAVED	WATER FROM SURFACE
9 ft.	Brown Clay & Sand	9 ft.		
6 ft.	Brown Sand, Clay & Larger Stones	15 ft.		
12 ft.	Brown Sand, Gravel & Clay	27 ft.		
8 ft.	Gray Sand, Smaller Gravel & Clay	35 ft.		
	Test hole converted to a 2" water sample hole, screened 15 - 35 feet.			
	Static water level - 8' 6"			

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MASSILLON, OHIO

DRILLED FOR TRW Aircraft Components Group - Minerva, Ohio HOLE NO. W 4 S

DRILLED BY Alan Graber DRILLER COMPLETED Jan. 9, 19 85

LOCATION Approximately 65 ft. west of Relocated SR 183, 760 ft. south of Connector Rd.

THICKNESS OF STRATA	STRATA	TOTAL DEPTH	HEAVED	WATER FROM SURFACE
14 ft.	Brown Clay, Sand & Stones	14 ft.		
4 ft.	Brown Sand, Clay & Stones	18 ft.		
9 ft.	Gray Sand, Small Gravel & Clay with Some Large Stones	27 ft.		
15 ft.	Gray Sand, Gravel & Clay	42 ft.		
	Test hole converted to a 2" water sample hole, screened 18 - 38 feet.			
	Static water level - 10' 4"			

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MASSILLON, OHIO

DRILLED FOR TRW Aircraft Components Group - Minerva, Ohio HOLE NO. W5S

DRILLED BY Glyn Davis DRILLER COMPLETED Jan. 23, 19 85

LOCATION Approximately 35 feet east of state route 183 & 30 feet north of entrance road to plant

THICKNESS OF STRATA	STRATA	TOTAL DEPTH	HEAVED	WATER FROM SURFACE
6 ft.	Sandy Clay	6 ft.		
4 ft.	Brown Sand, Clay & Stones	10 ft.		
4 ft.	Brown Sand, Clay & Gravel	14 ft.		
12 ft.	Brown Sand, Gravel & Little Clay	26 ft.		
16 ft.	Gray Sand, Gravel & Little Clay	42 ft.		
	Test hole converted to a 2" water sample hole, screened 14 - 34 feet.			
	Static water level - 7' 6"			

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MASSILLON, OHIO

DRILLED FOR TRW Aircraft Components Group - Minerva, Ohio HOLE NO. W 6 S

DRILLED BY Alan Graber DRILLER COMPLETED Jan. 29, 19 85

LOCATION Approximately 430 feet north of W 5 S & 35 feet east of state route 183 center line

THICKNESS OF STRATA	STRATA	TOTAL DEPTH	HEAVED	WATER FROM SURFACE
8 ft.	Brown Sandy Clay & Stones	8 ft.		
6 ft.	Brown Sandy Clay	14 ft.		
7 ft.	Brown Sand, Clay & Some Gravel	21 ft.		
7 ft.	Brown Sand, Smaller Gravel, Clay & Larger Stones	28 ft.		
7 ft.	Gray Sand, Smaller Gravel & Clay	35 ft.		
	Test hole converted to a 2" water sample hole, screened 14 - 34 feet.			
	Static water level - 7' 6"			

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MASSILLON, OHIO

DRILLED FOR TRW Aircraft Components Group - Minerva, Ohio HOLE NO. 24-S
3" Test Hole

DRILLED BY Alan Graber DRILLER COMPLETED December 7, 19 84

LOCATION Approximately 100 feet north of Sandy Creek & 32 feet east of State Route 83

THICKNESS	STRATA	TOTAL DEPTH	HEAVED	WATER FROM SURFACE
6 ft.	Sandy Clay	6 ft.		
7 ft.	Sand, Clay & Large Gravel	13 ft.		
4 ft.	Sand, Some Gravel & Clay	17 ft.		
	Test hole converted to a 2" water sample hole, screened 3.5 to 13.5 feet.			
	Static water level - 4' 5"			
	Water sample collected at 3.5 - 13.5 feet			

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MASSILLON, OHIO

DRILLED FOR TRW Aircraft Components Group - Minerva, Ohio HOLE NO. 22-M
3" Test Hole

DRILLED BY Alan Graber DRILLER COMPLETED Nov. 20, 19 84

LOCATION Approximately 150 ft. down gradient from test hole #19

THICKNESS OF STRATA	STRATA	TOTAL DEPTH	HEAVED	WATER FROM SURFACE
7 ft.	Brown Clay, Sand & Few Stones	7 ft.		
5 ft.	Gray Sand, Clay & Gravel	12 ft.		
7 ft.	Brown Sand, Clay & Gravel	19 ft.		
6 ft.	Brown Sand, Few Small Stones & Clay	25 ft.		
7 ft.	Gray Sand, Small Gravel & Clay (layered)	32 ft.		
7 ft.	Gray Sand, Gravel & Clay	39 ft.	yes	
21 ft.	Gray Sand, Some Gravel & Clay	60 ft.		
20 ft.	Gray Sand, Gravel & Clay	80 ft.		
6 ft.	Gray Sand, Gravel & Little Clay	86 ft.	yes	
12 ft.	Gray Sand, Gravel & Clay	98 ft.		
8 ft.	Gray Sand, Small Gravel & Clay	106 ft.		
13 ft.	Gray Sand, Smaller Gravel & Little Clay	119 ft.		
14 ft.	Gray Sand, Smaller Gravel & Clay	133 ft.		
7 ft.	Gray Sand, Gravel & Little Clay	140 ft.		
10 ft.	Gray Sand, Smaller Gravel & Clay	150 ft.		
1 ft.	Limestone	151 ft.		

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MASSILLON, OHIO

DRILLED FOR TRW Aircraft Components Group - Minerva, Ohio HOLE NO. 22-M
3" Test Hole

DRILLED BY Alan Graber DRILLER COMPLETED Nov. 20, 19 84

LOCATION Approximately 150 ft. down gradient from test hole #19

THICKNESS OF STRATA	STRATA	TOTAL DEPTH	HEAVED	WATER FROM SURFACE
	Test hole converted to a 2" water sample hole, screened from 30 to 40 feet.			
	Static water level - 4' 10"			
	Water samples collected:	29 to 32 ft.		
		43 to 46 ft.		
		57 to 60 ft.		
		70 to 73 ft.		
		83 to 86 ft.		
		96 to 99 ft.		
		110 to 113 ft.		
		123 to 126 ft.		
		137 to 140 ft.		

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MASSILLON, OHIO

DRILLED FOR TRW Aircraft Components Group - Minerva, Ohio HOLE NO. 23-M

DRILLED BY Alan Graber DRILLER COMPLETED Dec. 5, 19 84

LOCATION Approximately 135 feet down gradient from test hole #13

THICKNESS OF STRATA	STRATA	TOTAL DEPTH	CAVED	WATER FROM SURFACE
7 ft.	Sandy Clay	7 ft.		
14 ft.	Brown Sand, Clay & Gravel	21 ft.		
7 ft.	Brown Sand, Gravel & Clay	28 ft.		
14 ft.	Gray Sand, Gravel & Clay	42 ft.		
21 ft.	Gray Sand, Gravel & Little Clay	63 ft.	yes	
15 ft.	Gray Sand, Gravel & Clay	78 ft.		
14 ft.	Brownish Gray Sand, Gravel & Clay (dirty)	92 ft.		
	Test hole converted to a 2" water sample hole, screened 3.5 to 13.5 feet.			
	Static water level - 5'2"			
	Water samples collected -	5 ft.		
		18 - 21 ft.		
		32 - 35 ft.		
		46 - 49 ft.		
		60 - 63 ft.		
		75 - 78 ft.		
		89 - 92 ft.		

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MASSILLON, OHIO

DRILLED FOR TRW Aircraft Components Group - Minerva, Ohio HOLE NO. W 4 M
3" Test Hole

DRILLED BY Glynn Davis DRILLER COMPLETED Nov. 26, 19 84

LOCATION Approximately
135 feet south of red barn and 20 feet west of state route 183

THICKNESS OF STRATA	STRATA	TOTAL DEPTH	HEAVED	WATER FROM SURFACE
6 ft.	Clay & Sand	6 ft.		
6 ft.	Brown Sand, Clay & Stones	12 ft.		
9 ft.	Brown Sand, Gravel & Clay	21 ft.		14' 6"
14 ft.	Brown Sand, Smaller Gravel & Little Clay	35 ft.		14' 6"
18 ft.	Gray Sand, Gravel & Clay (tight)	53 ft.		
1 ft.	Gray Sandy Clay	54 ft.		
1 ft.	Gray Sandy Shale	55 ft.		
	Test hole converted to a 2" water sample hole, screened 15 to 25 feet.			
	Static water level - 14' 6"			
	Water samples collected:	14 to 18 ft.		
		28 to 32 ft.		
		52 to 53 ft.		
	Water entered hole very slowly when screened 14 to 18 feet.			

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MASSILLON, OHIO

DRILLED FOR TRW Aircraft Components Group - Minerva, Ohio HOLE NO. TB-1

DRILLED BY Alan Graber DRILLER COMPLETED Feb. 12, 19 85

LOCATION 100 feet east of well 22M

THICKNESS OF STRATA	STRATA	TOTAL DEPTH	HEAVED	WATER FROM SURFACE
5 ft.	Brown Sandy Clay	5 ft.		
9 ft.	Gray Clay, Sand & Gravel	14 ft.		
	Static water level - 4' 0"			

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MASSILLON, OHIO

DRILLED FOR TRW Aircraft Components Group - Minerva, Ohio HOLE NO. TB-2

DRILLED BY Alan Graber DRILLER COMPLETED Feb. 12, 19 85

LOCATION 100 feet south of 22M

THICKNESS OF STRATA	STRATA	TOTAL DEPTH	HEAVED	WATER FROM SURFACE
6 ft.	Brown Sandy Clay	6 ft.		
8 ft.	Gray Sand, Clay & Gravel	14 ft.		
	Static water level - 4' 7"			

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MASSILLON, OHIO

DRILLED FOR TRW Aircraft Components Group - Minerva, Ohio HOLE NO. TB-3

DRILLED BY Alan Graber DRILLER COMPLETED Feb. 12, 19 85

LOCATION 141 feet southeast of 22M

THICKNESS OF STRATA	STRATA	TOTAL DEPTH	HEAVED	WATER FROM SURFACE
4 ft.	Brown Sandy Clay	4 ft.		
3 ft.	Brown Sandy Clay & Stones	7 ft.		
7 ft.	Gray Sand, Clay & Gravel	14 ft.		
	Static water level - 5' 2"			

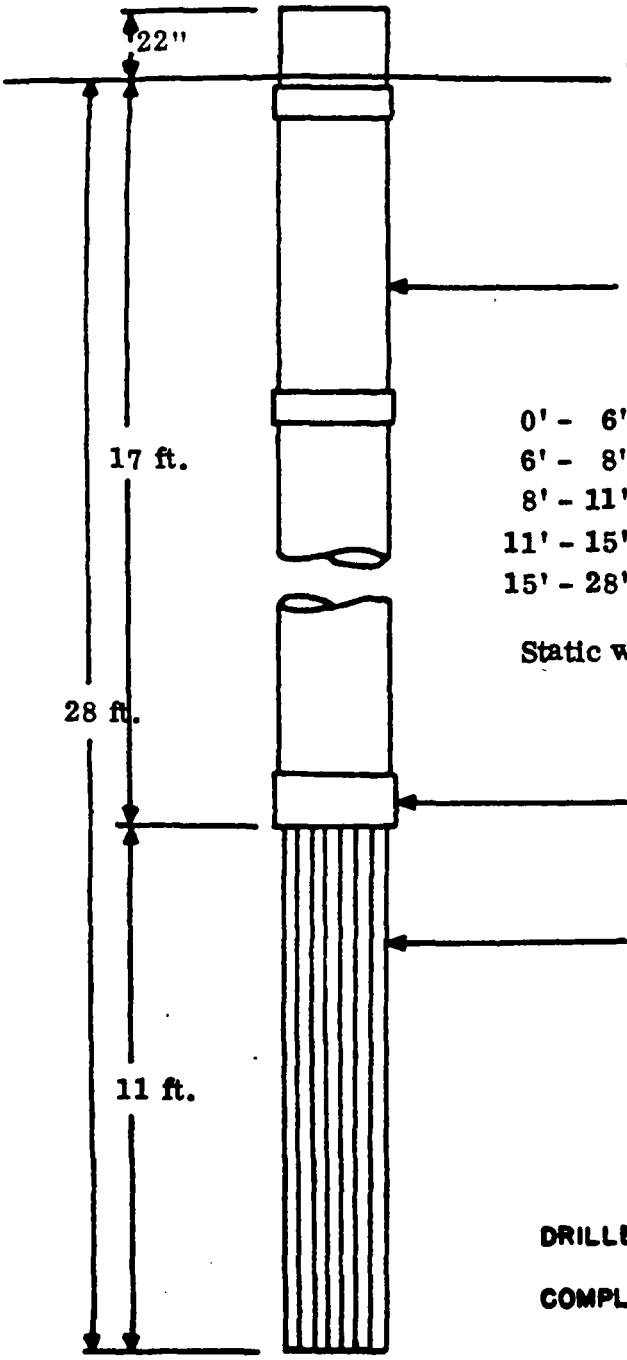
THE OHIO DRILLING COMPANY
MASSILLON, OHIO

TRW - Minerva, Ohio

Well No. TW-1

Test Pump Installed

Ford engine with right angle drive
15 feet of 6" column
10" bowl assembly - 5 feet long
7 feet of 6" suction



CASING 12" diameter with banded and welded joints

0' - 6' Clay & Sand
6' - 8' Sand, Clay & Gravel
8' - 11' Sand, Clay & Little Gravel
11' - 15' Sand, Gravel & Clay
15' - 28' Sand, Gravel & Little Clay

Static water level - 2' 8"

SCREEN Stainless steel, 12" nominal diameter with bail bottom

DRILLED BY: Glyn Davis

COMPLETED: December 18, 1984

THE OHIO DRILLING CO.

INCORPORATED

MASSILLON, OHIO

DRILLED FOR TRW Aircraft Components Group - Minerva, Ohio HOLE NO. R-1 (C)

DRILLED BY Alan Graber DRILLER COMPLETED Feb. 4, 19 85

LOCATION 66 feet south of Market St., approximately 1950 feet west of Rt. 183

THICKNESS OF STRATA	STRATA	TOTAL DEPTH	HEAVED	WATER FROM SURFACE
4 ft.	Brown Sandy Clay	4 ft.		
4 ft.	Brown Sand, Clay & Gravel	8 ft.		
6 ft.	Gray Clay, Sand & Gravel	14 ft.		
7 ft.	Gray Sand, Few Stones & Clay	21 ft.		
6 ft.	Gray Sand, Some Gravel & Clay	27 ft.		
	Static water level - 5' 0"			
	Inserted 14 ft. of 2" pipe with 10 ft. of screen at bottom.			

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MASSILLON, OHIO

DRILLED FOR TRW Aircraft Components Group - Minerva, Ohio HOLE NO. R-2(B)

DRILLED BY Alan Graber DRILLER COMPLETED Feb. 6, 19 85

LOCATION Approximately 1320 feet south of Market St., 25 feet west of Delmar St.

THICKNESS OF STRATA	STRATA	TOTAL DEPTH	HEAVED	WATER FROM SURFACE
7 ft.	Brown Sandy Clay & Stones	7 ft.		
3 ft.	Gray Clay, Sand & Stones	10 ft.		
7 ft.	Brown Sand, Clay, Gravel & Stones	17 ft.		
11 ft.	Gray Sand, Gravel & Clay	28 ft.		
	Static water level - 8' 0"			
	Inserted 17 ft. of 2" pipe with 10 ft. of screen at bottom.			

THE OHIO DRILLING CO.

INCORPORATED

MASSILLON, OHIO

DRILLED FOR TRW Aircraft Components Group - Minerva, Ohio HOLE NO. R-3 (A)

DRILLED BY Alan Graber DRILLER COMPLETED Feb. 7, 19 85

LOCATION 408 ft. west of W2S, 25 ft. north of Market Street

THICKNESS OF STRATA	STRATA	TOTAL DEPTH	HEAVED	WATER FROM SURFACE
2 ft.	Fill, Sand & Large Stones	2 ft.		
10 ft.	Sandy Clay & Small Gravel	12 ft.		
13 ft.	Shale	25 ft.		None

APPENDIX 8

Pump Test Results

PUMPING TEST DATA SHEET THE OHIO DRILLING CO.

FOR: TRW, Minerva, Ohio DATE: 2-18-85

STA. #19

SWL 6.57

DISTANCE FROM PUMPED WELL = 19'.

TIME	HOLD	CUT	W.L.	FL.T.	D.D.	REMARKS
09:17			6.58	swl		Staff guages installed in Dutch & Sandy Creek
10:21			6.57	"		SWL in TW1 = 4.38'
11:14			6.57	"		
12:12			6.58	"		No movement on staff guages.
13:25			6.57	"		
14:15			6.57	"		
15:05			6.57	"		No movement on staff guages.
15:20				0		START PUMPING, ADJUST RATE TO 320 GPM.
15:22			7.36	2	.79	
15:23			7.40	3	.83	
15:24			7.46	4	.89	
15:25			7.51	6	.93	
15:27			7.55	8	.98	
15:28			7.56	9	.99	
15:31			7.58	11	1.01	
15:41			7.68	21	1.11	
15:46			7.69	26	1.12	
15:58			7.73	38	1.16	
16:04			7.74	44	1.17	@16:09 Staff guages up by 0.04'.
16:14			7.77	54	1.20	PWL in TW1 is 13.75'
16:23			7.87	63	1.30	PWL in TW1 is 12.81'
16:56			7.81	96	1.24	
17:29			7.85	121	1.28	PWL in TW1 is 13.82'
18:44			7.92	204	1.35	
19:33			7.90	253	1.33	@ 19:40 Staff guages down by 0.01'.
20:41			7.95	321	1.38	PWL in TW1 is 13.92'
23:43			7.97	503	1.40	Staff guages stable.
03:15			8.02	715	1.45	" " "
07:45			8.04	985	1.47	Staff guages stable.
10:45			8.06	1045	1.49	
12:07			8.06	1127	1.49	PWL in TW1 is 14.08'
15:05			8.06	1425	1.49	Staff guages stable.
15:20			8.06	1440	1.49	PWL in TW1 is 14.09'
15:33				1453		CEASED PUMPING - BEGAN RECOVERY
15:34			7.66	1	1.09	
15:35			7.55	2	.98	
15:36			7.50	3	.92	
15:37			7.45	4	.88	
15:38			7.44	5	.87	

PUMPING TEST DATA SHEET THE OHIO DRILLING CO.

FOR: TRW, MINERVA, OHIO DATE: 2-19-84

STA. #19

SWL 6.57'

TIME	HOLD	CUT	W.L.	EL.T.	D.D.	REMARKS
15:39			7.46	6	.89	
15:40			7.41	7	.84	
15:41			7.39	8	.82	
15:42			7.37	9	.80	
15:44			7.36	11	.79	
15:46			7.31	13	.74	
15:48			7.30	15	.73	
15:50			7.29	17	.72	
15:53			7.26	20	.69	
15:57			7.24	24	.67	
16:01			7.22	28	.65	
16:23			7.13	50	.56	
16:56			6.97	83	.40	Staff guages stable.
17:38			6.95	125	.38	
18:04			6.94	151	.37	
18:51			6.96	198	.39	
21:33			6.87	402	.30	
23:36			6.84	525	.27	

PUMPING TEST DATA SHEET THE OHIO DRILLING CO.

FOR: TRW, Minerva, Ohio DATE: 2-18-84

STA. #10

SWL 6.94

TIME	HOLD	CUT	W.L.	EL.T.	D.D.	REMARKS
09:20			6.94	swl	—	
10:24			6.95	"	—	
11:17			6.94	"	—	
12:15			6.95	"	—	
13:30			6.94	"	—	
14:18			6.94	"	—	
15:08			6.94	"	—	
15:20	Start Pumping 320 GPM					
15:34			7.23	14	.29	
15:49			7.35	29	.41	
16:16			7.42	56	.48	
16:58			7.50	98	.56	
18:47			7.63	207	.69	
19:36			7.67	256	.73	
20:43			7.70	323	.76	
23:48			7.74	508	.80	
02:18			7.78	718	.84	
07:48			7.81	988	.87	
10:47			7.85	1167	.91	
12:10			7.85	1250	.91	
15:09			7.85	1429	.91	
15:33	Stopped Pumping.		0			Begin Recovery
16:03			7.55	30	.61	
16:59			7.41	86	.47	
17:40			7.34	127	.40	
18:56			7.22	203	.28	
21:33			7.13	405	.19	
23:41			7.08	529	.14	

PUMPING TEST DATA SHEET THE OHIO DRILLING CO.

FOR: TRW - Minerva, Ohio DATE: 2-18-85

STA. #18

SWL 5.06

TIME	HOLD	CUT	W.L.	EL.T.	D.D.	REMARKS
09:23			5.06	SWL		
10:27			5.07			
11:20			5.04			
12:19			5.05			
13:45			5.06			
14:22			5.06			
15:13			5.06			
15:20						START PUMPING 320 GPM
15:36			5.49	16	.43	
15:51			5.55	31	.49	
16:18			5.62	58	.56	
17:61			5.66	101	.60	
18:50			5.74	210	.68	
20:46			5.79	326	.73	
23:50			5.81	510	.75	
03:21			5.84	721	.78	
07:50			5.87	990	5.87	
10:51			5.90	1171	.84	
12:12			5.90	1252	.84	
15:11			5.91	1431	.84	
15:33				0		Stopped Pumping
16:05			5.50	32	.44	
17:00			5.39	87	.33	
17:42			5.33	129	.27	
18:59			5.29	206	.23	
21:32			5.22	408	.16	
23:43			5.19	532	.13	

PUMPING TEST DATA SHEET THE OHIO DRILLING CO.

FOR: TRW - Minerva, Oh. DATE: 2-18-84

STA. #9

SWL 6.05

TIME	HOLD	CUT	W.L.	EL.T.	D.D.	REMARKS
09:26			6.04	swl		
10:30			6.04	"		
11:23			6.04	"		
12:22			6.05	"		
13:49			6.05	"		
14:25			6.05	"		
15:16			6.05	"		
15:20						STARTED PUMPING
15:38			6.09	18	.04	
15:54			6.13	54	.08	
16:20			6.15	60	.10	
17:03			6.20	103	.15	
18:53			6.23	213	.18	
20:48			6.28	328	.23	
23:53			6.31	513	.27	
03:24			6.35	724	.30	
07:52			6.40	992	.35	
10:53			6.41	1173	.36	
12:15			6.41	1255	.36	
15:11			6.41	1431	.36	
15:33				0		Stopped Pumping / Begin Recovery
16:08			6.31	35	.26	
17:02			6.25	89	.20	
17:45			6.23	132	.18	
21:35			6.14	411	.10	
23:46			6.11	535	.07	

PUMPING TEST DATA SHEET THE OHIO DRILLING CO.

FOR: TRW - Minerva, Oh DATE: 2-18-85

STA. 22+11

SWL 6.50'

TIME	HOLD	CUT	W.L.	EL.T.	D.D.	REMARKS
09:33			6.50	SWL		
10:36			6.47			
11:30			6.50			
12:29			6.50			
13:56			6.50			
14:32			6.51			
15:19			6.50	0		
15:20				0		Started pumping.
15:44			6.77	24	.27	
16:01			6.80	41	.30	
16:26			6.82	66	.32	
17:07			6.86	107	.36	
18:59			6.88	219	.38	
20:56			6.91	336	.41	
03:27			6.95	727	.45	
07:56			6.98	996	.48	
10:59			6.99	1179	.49	
12:22			6.99	1222	.49	
15:18			6.99	1438	.49	
15:33				0		Stopped pumping
16:12			6.70	39	.20	
17:08			6.66	95	.16	
17:49			6.63	136	.13	
21:42			6.55	418	.05	
23:53			6.54	542	.04	

PUMPING TEST DATA SHEET THE OHIO DRILLING CO.

FOR: TRW - Minerva, Oh DATE: 2-18-85

STA. 22M

SWL 6.50'

TIME	HOLD	CUT	W.L.	EL.T.	D.D.	REMARKS
09:33			6.50	SWL		
10:36			6.47			
11:30			6.50			
12:29			6.50			
13:56			6.50			
14:32			6.51			
15:19			6.50	0		
15:20				0		Started pumping.
15:44			6.77	24	.27	
16:01			6.80	41	.30	
16:26			6.82	66	.32	
17:07			6.86	107	.36	
18:59			6.88	219	.38	
20:56			6.91	336	.41	
03:27			6.95	727	.45	
07:56			6.98	996	.48	
10:59			6.99	1179	.49	
12:22			6.99	1222	.49	
15:18			6.99	1438	.49	
15:33				0		Stopped pumping
16:12			6.70	39	.20	
17:08			6.66	95	.16	
17:49			6.63	136	.13	
21:42			6.55	418	.05	
23:53			6.54	542	.04	

PUMPING TEST DATA SHEET THE OHIO DRILLING CO.

FOR: TRW - MINERVA, OHIO DATE: 2-18-85

STA. #12

SWL 7.92'

TIME	HOLD	CUT	W.L.	EL.T.	D.D.	REMARKS
09:02	"		7.92			
10:12	"		7.92			
11:04	"		7.92			
12:05			7.92			
13:00			7.93			
14:02			7.92			
5:09			7.92			
15:20				0	0	Start pumping 320 GPM
15:36			7.92	15	—	
15:55			7.92	35	—	
16:15			7.92	55	—	
17:03			7.96	103	.04	
19:20			8.17	240	.25	
21:16			8.25	456	.33	
23:10			8.42	570	.50	
08:37			8.58	1037	.66	
10:47			8.58	1167	.66	
13:21			8.60	1321	.68	
15:09			8.60	1429	.68	
15:33				0		Shutdown pump.
16:04			8.52	31	.60	
17:11			8.52	98	.60	
17:43			8.48	130	.56	
19:10			8.39	217	.47	
23:31			8.19	530	.27	

PUMPING TEST DATA SHEET THE OHIO DRILLING CO.

FOR: TRW - MINERA DATE: 2-18 85

STA. # 11

SWL 8.08'

TIME	HOLD	CUT	W.L.	EL.T.	D.D.	REMARKS
09:07			8.09			
10:03			8.09			
11:10			8.08			
12:08			8.08			
13:20			8.08			
15:11			8.08			
15:20				0		Start Pumping 320 GPM
15:38			8.33	12	.25	
15:58			8.50	38	.42	
16:18			8.54	58	.46	
17:07			8.54	107	.46	
19:23			8.71	243	.63	
21:18			8.71	358	.63	
23:13			8.76	573	.68	
08:40			8.85	1040	.77	
10:50			8.85	1170	.77	
13:24			8.85	1324	.77	
15:11			8.85	1431	.77	
15:33				0		Shutdown pump.
16:06			8.60	33	.52	
17:05			8.46	92	.38	
17:46			8.40	133	.32	
19:14			8.34	221	.26	
23:36			8.24	535	.16	

PUMPING TEST DATA SHEET THE OHIO DRILLING CO.

FOR: TRW - Minerva, Ohio DATE: 2-18-85

STA. #21

SWL 7.33

TIME	HOLD	CUT	W.L.	F.L.T.	D.D.	REMARKS
09:13			7.32			
10:15			7.32			
11:16			7.33			
12:13			7.32			
13:12			7.33			
14:03			7.33			
15:20				0	0	Start pumping
15:39			7.33	19	0	
16:02			7.46	43	.13	
16:24			7.46	64	.13	
17:14			7.50	114	.17	
19:29			7.71	249	.38	
21:25			7.71	365	.38	
23:47			7.76	546	.43	
08:45			7.83	1045	.50	
10:55			7.85	1175	.52	
13:32			7.85	1332	.52	
15:17			7.85	1437	.52	
15:33				0		Shutdown pumping
16:14			7.75	41	.42	
17:12			7.74	99	.41	
17:52			7.54	139	.21	
19:21			7.56	228	.23	
23:42			7.46	541	.13	

PUMPING TEST DATA SHEET THE OHIO DRILLING CO.

FOR: TRW - Minerva, Ohio DATE: 2-18-85

STA. #20

SWL 7.87'

TIME	HOLD	CUT	W.L.	E.L.T.	D.D.	REMARKS
09:17			7.88			
10:19			7.88			
11:21			7.87			
12:17			7.87			
13:06			7.88			
14:07			7.87			
15:14			7.87			
15:20				0		started pumping
15:42			8.04	22	.17	
15:59			8.42	39	.55	
16:21			8.50	61	.63	
17:12			8.52	112	.65	
19:25			8.60	245	.73	
21:21			8.71	361	.84	
22:17			8.76	577	.89	
08:42			8.83	1042	.96	
10:52			8.83	1172	.96	
13:15			8.85	1315	.98	
15:14			8.88	1437	1.01	
15:33				0		shut down pump
15:37			8.75	4	.88	
15:38			8.67	5	.80	
15:39			8.67	6	.80	
15:40			8.67	7	.80	
15:41			8.66	8	.79	
15:43			8.67	10	.78	
15:45			8.63	12	.76	
15:47			8.61	14	.74	
15:49			8.59	16	.72	
15:51			8.57	18	.70	
15:56			8.54	23	.67	
16:01			8.52	28	.65	
16:10			8.51	37	.64	
17:08			8.33	95	.55	
15:49			8.29	136	.42	
19:13			8.19	210	.32	
23:08			8.06	507	.19	

PUMPING TEST DATA SHEET THE OHIO DRILLING CO.

FOR: TRW - Minerva, Ohio DATE: 2-18-85

STA. 23m

SWL 6.04'

TIME	HOLD	CUT	W.L.	E.L.T.	D.D.	REMARKS
09:23			6.04			
10:22			6.04			
11:26			6.04			
12:24			6.04			
13:25			6.04			
14:19			6.04			
15:20				0		start pumping
15:45			6.08	25	.04	
16:10			6.25	50	.21	
16:28			6.25	68	.21	
17:19			6.24	119	.22	
19:35			6.35	255	.31	
21:32			6.38	372	.34	
23:31			6.40	530	.36	
08:49			6.42	1049	.38	
11:01			6.42	1181	.38	
13:07			6.44	1307	.40	
15:21			6.46	1441	.42	
15:37				0		stopped pumping
16:19			6.31	46	.27	
17:16			6.25	103	.21	
17:57			6.21	144	.17	
19:06			6.16	213	.12	
23:21			6.11	520	.07	

PUMPING TEST DATA SHEET THE OHIO DRILLING CO.

FOR: TRW - Minerva DATE: 2-18-84

STA. W25

SWL 10.85'

TIME	HOLD	CUT	W.L.	EL.T.	D.D.	REMARKS
09:16			10.84	SWL		
10:18			10.85			
11:12			10.85			
12:16			10.85			
13:10			10.85			
14:20			10.85			
15:18			10.85			
15:20			0			START PUMPING AT 320 GPM
15:47			11.08	27	.23	
16:15			11.08	55	.23	
16:33			11.10	73	.25	
17:15			11.15	115	.30	
20:01			11.17	281	.32	
22:05			11.22	465	.37	
08:50			11.29	1050	.44	
11:02			11.29	1209	.44	
12:04			11.29	1271	.44	
15:23			11.29	1453	.44	
15:33				0		Shutdown
16:06			11.08	33	.23	
16:08			11.08	35	.23	
17:15			11.04	102	.19	
17:56			11.04	143	.19	
19:58			11.04	265	.19	
23:26			11.03	472	.18	

PUMPING TEST DATA SHEET THE OHIO DRILLING CO.

FOR: TRW - MINERVA, OHIO DATE: 2-18-85

STA. W15

SWL 11.58'

TIME	HOLD	CUT	W.L.	EL.T.	D.D.	REMARKS
09:06			11.58	SWL		
10:08			11.59			
11:01			11.58			
12:06			11.58			
13:01			11.58			
14:09			11.58			
15:07			11.58			
15:20				0	0	START PUMPING 320 GPM
15:35			11.96	15	.38	
16:02			11.96	42	.38	
16:22			12.04	62	.46	
17:01			12.06	104	.48	
19:45			12.21	265	.63	
20:04			12.15	344	.57	
23:02			12.17	462	.59	
08:38			12.25	1038	.67	
10:48			12.25	1168	.67	
12:14			12.25	1254	.67	
15:09			12.25	1429	.67	
15:33				0		STOPPED PUMPING
15:35			12.10	2	.52	
15:36			12.04	3	.46	
15:37			12.02	4	.44	
15:38			12.02	5	.44	
15:40			12.00	7	.42	
15:41			11.96	8	.38	
15:42			11.96	9	.38	
15:44			11.96	10	.38	
15:45			11.94	11	.36	
15:46			11.94	12	.36	
15:48			11.92	14	.34	
15:50			11.92	16	.34	
16:14			11.88	40	.30	
17:02			11.81	98	.23	
17:42			11.79	128	.21	
19:50			11.78	256	.20	
23:20			11.77	466	.19	

PUMPING TEST DATA SHEET THE OHIO DRILLING CO.

FOR: TRW - MINERVA, OHIO DATE: 2-18-85

STA. IVAS

SWL 11.69'

TIME	HOLD	CUT	W.L.	F.L.T.	D.D.	REMARKS
09:14			11.69			
10:15			11.69			
11:09			11.69			
12:16			11.69			
13:09			11.68			
15:15			11.69			
15:20				0	0	START PUMPING 320 GPM
15:42			11.85	22	.16	
16:10			11.94	50	.25	
16:28			11.94	68	.25	
17:10			11.94	110	.25	
19:54			11.96	274	.27	
23:09			11.98	469	.29	
08:45			12.02	1045	.33	
10:56			12.02	1176	.33	
15:16			12.03	1436	.34	
15:33				0		SHUTDOWN PUMP
15:59			11.83	26	.14	
16:01			11.83	28	.14	
17:09			11.82	96	.13	
19:56			11.82	262	.13	
23:30			11.81	476	.12	

PUMPING TEST DATA SHEET THE OHIO DRILLING CO.

FOR: TRW-Minerva DATE: 2-18-85

STA. W3S

SWL 10.38

TIME	HOLD	CUT	W.L.	E.L.T.	D.D.	REMARKS
09:09			10.38			
10:11			10.38			
11:04			10.38			
12:10			10.40			
13:04			10.38			
14:12			10.38			
15:10			10.38			
15:20				0		Begin Pumping at 320 GPM
15:37			10.58	17	.20	
16:05			10.67	45	.29	
16:25			10.71	65	.33	"
17:06			10.71	108	.33	
19:49			10.77	269	.39	
20:07			10.73	347	.35	
23:30			10.78	476	.40	
09:11			10.81	1041	.43	
10:52			10.83	1172	.45	
15:12			10.83	1432	.45	
15:33				0		Shutdown pump
15:53			10.69	20	.31	
15:55			10.67	22	.29	
17:05			10.58	92	.20	
17:45			10.58	132	.20	
19:53			10.57	259	.19	
23:23			10.57	469	.19	

APPENDIX 9

Groundwater Flow Modeling Report

non responsive

non responsive

non responsive

non responsive

non responsive

non responsive

non responsive

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non responsive

non responsive

non responsive

non responsive

non responsive

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